RAILROAD AND ENGINEERING JOURNAL

NEW YORK [ETC.]

V. 62, 1888

(Established 1832.)

THE RAILROAD AND ENGINEERING JOURNAL.

The AMERICAN RAILROAD JOURNAL and VAN NOSTRAND'S ENGINEERING MAGAZINE have been consolidated in this publication.

VOLUME LXII.

[VOLUME II, NEW SERIES.]

1888.

Published Monthly, at 45 Broadway, New York, by

M. N. FORNEY.

INDEX.

VOLUME LXII.

(VOLUME II, NEW SERIES.)

1888.

ILLUSTRATIONS.

ILLUSTRATIONS.

EDITORIALS.

EDITORIALS.

NEW PUBLICATIONS.

NEW PUBLICATIONS.

CONTRIBUTIONS.

MISCELLANEOUS ARTICLES.

MISCELLANEOUS ARTICLES.

PROCEEDINGS OF SOCIETIES.

PERSONAL NOTES.

PERSONAL NOTES.

NOTES AND NEWS.

NOTES AND NEWS.

THE RAILROAD AND

ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

PUBLISHED MONTHLY AT NO. 45 BROADWAY, NEW YORK.

M. N. FORNEY, ... Editor and Proprietor.
FREDERICK HOBART. . . . . Associate Editor.

Entered at the Post Office at New York City as Second-Class Mail Matter.

SUBSCRIPTION RATES.

Subscription, per annum, Postage prepaid	$3 00
Subscription, per annum, Foreign Countries	3 50
Single copies	25

Remittances should be made by Express Money-Order, Draft, P. O. Money-Order or Registered Letter.

MR. J. HOWARD BARNARD, 7 Montgomery Avenue, San Francisco, Cal., is the authorized Western Agent for the JOURNAL.

MR. FREDERIC ALGAR, Nos. 11 and 12 Clements Lane, Lombard Street, London, E. C., England, is the authorized European Agent for the JOURNAL.

NEW YORK, JANUARY, 1888.

THE files of the JOURNAL now in its office are complete from the first establishment of the AMERICAN RAILROAD JOURNAL in 1832 up to the present date, with the exception of the numbers from January 1, 1881, to September 10, 1881, and for May, 1885. If any of our old subscribers have in their possession copies of those numbers, or of any of them, and are willing to part with them, they will confer a favor on the JOURNAL by sending notice thereof to its office. In such case the new JOURNAL will be exchanged for the old, by crediting the subscriber for a time corresponding to the back numbers sent in.

FURTHER unfavorable reports continue to come from the Panama Canal. The latest examination made by a competent engineer confirms the statements heretofore made, to the effect that less than one-quarter of the work is done, and that the part which remains to be completed includes the most difficult and expensive sections of the canal. There is no possibility that the canal can be opened at the date set by M. de Lesseps, and there is no probability that it will be completed at all unless there is a change in the plans and methods of the company.

The financial as well as the engineering department of the company seems to be in a bad way. There is much talk of a new loan, but it seems hardly probable that such a loan could be taken except at a discount even more ruinous than the last. How much longer the company can carry its financial burden seems to depend chiefly upon whether it can obtain some guarantee from the French Government.

Meanwhile the Nicaragua Canal people promise to push their surveys, and claim that they are ready to begin work as soon as the plans are completed. Their canal is a sufficiently formidable undertaking, but has certainly better prospects from an engineering point of view. The obstacles are less formidable than at Panama, and the work is all of such a nature that the cost can be fairly estimated; and the chief difficulty will be to provide the money.

THE new President of the French Republic, M. Sadi-Carnot, is a civil engineer by profession, and has served as a subordinate and as Chief of a division in the department of *Ponts et Chausées*. He is one of the few civil engineers who have ever risen to high political office. Why the list is so short, it is, perhaps, not difficult to say. A good civil engineer ought to be a good public officer; he must have some executive ability, and must be accustomed to the conduct of affairs on a large scale. The civil engineer, however, is rarely an orator, or even a good talker; he is more a man of action than of words, and, moreover, has usually little time to devote to politics. He is out of the line of promotion, in which a lawyer, for instance, is usually found. Perhaps it would be better for the world at large if the engineer rather than the lawyer were chosen oftener than is now the case.

THE recommendation of the Secretary of War that guns of modern pattern be supplied to all posts where artillery is stationed, for purposes of practice, seems an eminently sensible one. A good artilleryman cannot be made out of raw material in a short time, like an infantry soldier; he is the skilled laborer, the mechanic of the service, and must have time to learn his business. And if he is ever to be called on to do actual service, it is only reasonable to give him a chance to learn to know and use his tools beforehand. Big guns will be of very little use, if they are ever really needed, unless there are men familiar with their use.

THE new cruiser *Atlanta*, according to the report of her commander, Captain Bunce, is faulty in many respects, and will need a general reconstruction before she becomes an efficient part of the Navy. Some of the changes are slight and could easily be made, probably with advantage. Most of the criticisms, however, are directed not so much against the *Atlanta* alone as against the general type of cruiser which she represents; and if all these are to be met the building of a new ship will be practically what will be required.

With regard to Captain Bunce's recommendations, there was, as might have been expected, much difference of opinion at the Navy Department. The Secretary, however, has taken what appears to be the most sensible course, and has ordered that no changes be made until after extended trials at sea.

THE latest development of the demand for increased facilities for passenger transit in New York City is a plan for a tunnel or underground road from the Grand Central Depot in Forty-second Street to the Battery, which, with the existing line from the Grand Central north, would make a new line from the Battery to Harlem. It is, after all, only a revival of an old project, with some changes in the route. Some of the city papers assert positively that the necessary capital has been secured; but there is some doubt about this, and the company has not yet been fully organized.

A part of the plan is a branch from the City Hall to the Hudson River, to be extended under the river to a connection with the Pennsylvania Railroad in Jersey City. The whole project is an extensive one, but some doubt still remains as to its prospects.

THE elevation of the Pennsylvania Railroad passenger tracks through Jersey City was recently apparently secured,

the authorities of the city having given their consent after a long delay, caused by the opposition of some local interests. The change is one that would be beneficial both to the railroad and to the city at large, while the amount of property which would be injured by it is comparatively small. The new elevated line was to be about a mile in length, and an iron structure somewhat similar to the elevated railroads in New York, but, of course, much stronger, as it was intended to carry the heaviest trains at high speed. Its construction would do away with a number of street crossings, including several at which there is a large traffic, while at all of them there is constant delay and danger from the frequent passing of trains. The advantages gained by the railroad were to be in the ability to handle trains more quickly, as it would not be necessary to reduce their speed, and in the freedom from continually recurring accidents and claims for damages.

The gain to the city in freeing its busiest streets from obstruction, and in greater security against personal injury to its citizens, would appear to be great. Nevertheless, the accomplishment of the work has been delayed for nearly a year by local opposition, and is now possibly defeated. Why this should be so, especially as the entire expense was to be borne by the company, and all that was asked of the city was to vacate a section of one street, is one of those puzzles in municipal government which are very hard for an outsider to make out.

The proposed improvement is entirely blocked for the present by legal proceedings. The company, it is stated, has resolved to take no further action toward securing consent to the building of the elevated line, but it feels the necessity of a change, and will consider the question of removing its passenger station to the present freight-docks at Harsimus Cove.

THE people of Philadelphia, or that portion of them more directly interested, have begun a movement to compel the Philadelphia & Reading Railroad to elevate the tracks leading to its stations in that city. It is proposed at the same time that the two city stations of the company, on Callowhill Street and at Ninth and Green, shall be consolidated into one. The numerous street grade crossings now existing have become a dangerous nuisance, and the presence of the surface tracks in a crowded section of the city is a serious drawback to its improvement. An elevated line, similar to that by which the Pennsylvania Railroad reaches the Broad Street Station, is proposed.

That the change would be a great advantage to the city cannot be denied. The company has not been for a long time, and, indeed, is not now, in a position to pay for an improvement so expensive as this would be. It is not probable that the city would be willing to pay for it, and there will be much friction and discussion before the matter is finally settled. That an elevated line into the city will be the final result there is little doubt.

IT is not many years since the City of New York paid a large sum to secure the separation of the grades of the city streets and the Harlem (New York Central) tracks from Forty-second Street to the Harlem River, and now the residents of the city north of the river are calling for an extension of the work for their benefit. The rapid growth of the city northward has brought a dense population into the annexed district north of the Harlem, and the many grade crossings there are found to be both inconvenient and dangerous. The work would be an expensive one, and it is not probable that the company will undertake it willingly. Some pressure will be necessary, and there is no doubt that the city will be asked to pay part of the expense, as it was in the previous case. The matter has hardly reached a definite form yet, and may not for some time to come.

ALL these cases are different forms of a very difficult problem. In nearly all our large cities the railroad lines were built when the cities were comparatively small. The tracks passed over ground hardly yet occupied, and no one foresaw at the time the future extension of the cities or the great increase of the railroad traffic. The result has been that while the railroads and the cities have been necessary to each others' growth, they have also interfered with each other, and this mutual interference has gone on until it became unbearable. By that time the question of what was to be done has generally become a very difficult one to answer, from an engineering point of view as well as from a financial one. In New York, as in Philadelphia, Boston, Chicago, St. Louis, and other cities something has been done to solve the problems presented, but much still remains to be done. The danger in all such cases is the adoption of some temporary plan which may serve for a time, but will often be found to be in the end the worst and most costly way.

In this case a study of the plans adopted in London, Paris, Berlin, and other great cities abroad might be made with interest and profit to our engineers.

THE proposed lease of the Boston & Providence Railroad to the Old Colony Railroad Company is in the line of that consolidation which has for some years past been going on in New England. The period of consolidation came later there than in other sections of the country ; the companies were older and stronger, and were also kept more closely under legislative control than in other sections of the country, and consolidation has accordingly been more difficult. The question of large or small corporations has been sharply argued and fought over in nearly all the New England States, not only in the legislatures, but also by the railroad stockholders, who have a larger interest and own a greater proportion of the roads there than in other sections where railroads have been built largely on bonds, and have much heavier debts to carry.

Whatever opinion may be held from a political point of view, the engineer and manager sees many advantages on the side of the large companies. In this particular case the Boston & Providence road fits very well into the Old Colony system, and the advantages to be secured are such as probably to justify the payment of the high price asked for the leased line—10 per cent. on the stock and a cash bonus equivalent to over 25 per cent. on its par value.

The Boston & Providence Company is not only one of the oldest railroad corporations in the country, but it has also a very remarkable record. It was chartered in 1831, and the road was opened in 1835, or 52 years ago. It has paid dividends nearly every year since, and the total return to the stockholders for the 52 years reaches an average of about $7\frac{1}{2}$ per cent. a year. Nearly all the net earnings have gone to the stockholders, for the debt has always been small, and is even now only about one-fourth of the stock, although there is included in it the cost of the

Bussey Bridge accident, which has been well up toward half a million of dollars. It is remarkable also in being one of the few railroads in this country whose passenger earnings largely exceed those from freight, a condition to be expected, however, in a line connecting two large cities, both on navigable water.

A GEORGIA newspaper, speaking of the prospects of a local car-coupler inventor, says:

> There are 11,000,000 freight cars in the United States. At $1 per car per year, for the use of the patent, the proprietors would realize the magnificent sum of $11,000,000 per annum; and as the patent is good for 17 years, one can easily see what a fortune there is in this invention.

To say nothing of the probability—or improbability—of one coupler securing a place on all the cars in the country, our Georgia contemporary's estimate is a little out of the way. The last number of *Poor's Manual* gives the total number of freight-cars in the United States at about 846,000. Even allowing for omissions in the *Manual* and for new cars built this year, there must still be considerably less than a round million. The prospective income is thus at once divided by 11; and it is to be feared that the patent will have expired long before even this shrunken figure is reached.

THE trunk lines have agreed to adopt the new plan of charging for car service recommended by the Car Accountants' Association, and with this approval there is little doubt that it will be universally adopted. Under the new plan, as we have already noted, the simple mileage charge is replaced by a charge based about two-thirds on mileage and one-third on time. On the face of the matter this may seem to be complicating matters; but the new charge is very easily computed, and has the great merit that it enables a car to earn something when it is not in motion, and at the same time makes it an object to the company receiving it to return it as soon as possible. Under the old system this motive was entirely lacking.

FEW persons, even among railroad men, who have not made a special study of the subject, realize how great a loss is entailed upon railroad companies by idle freight cars. A car standing in a yard has, heretofore, been earning nothing for its owners, and the proportion of such cars unnecessarily detained when they were needed elsewhere has been so large that it must have involved an appreciable addition to the capital invested in freight rolling stock. How to keep their cars in motion so as to reduce the number needed to the lowest point and to enable them to earn interest on their cost is a problem which has taxed and still continues to tax the ingenuity of many railroad officers. If the introduction of the *per diem* charge will aid them, it will do a good work.

A MEETING was held in Chicago, December 7, for the purpose of securing some uniform method of settling joint freight accounts. There is now great diversity in methods of settlement, and much delay and confusion result. The present meeting had the indorsement of the accountants of many leading roads, and was very largely attended, but failed to take any decided action, although something was done toward securing the desired object, and arrangements were made for another meeting.

This meeting is another illustration of the complex nature of our railroad system, and of the continually recurring necessity of general action to secure uniformity in methods, which is felt in every department of the railroad service. The accountants, like their mechanical brethren, will not be able to reach the desired agreement unless they realize the necessity of making mutual concessions and the folly of insisting too strongly upon individual preferences.

AN AMERICAN RAILROAD UNION.

THE days when a person who was called a civil engineer was considered competent to direct *any* of "the great sources of power in nature for the use and convenience of man" are gone forever. Adam Smith showed the advantages of division of labor in the production of wealth, and pointed out that it was due to three causes:

1. The increase of dexterity in every particular workman. 2. The saving of time which is lost in going from one kind of work to another; and, 3. The invention of labor-saving machines.

Still another reason might be given for the division of labor in engineering—that is, the limited capacity of the human intellect. Engineering at the present time embraces such a wide field that no human being can now have anything like a thorough knowledge of more than a few special branches of the profession—if it is a distinct profession any longer. Fifty years ago an engineer was expected to be able to direct the building of a ship, locate a railroad, design its bridges and machinery, superintend the making of its rails, and, in short, supply the knowledge for doing anything and everything which needed to be done. All this has been changed, and year by year the process of subdivision of industries is carried farther and farther, so that now there are specialists for locating roads; the engineers who build iron bridges do not build wooden ones, and neither design nor construct stone structures. There are firms and companies who manufacture cars for passengers, and do not make any for carrying freight. The locomotive manufacturer does nothing else but build locomotives, and even he has his tires, axles, head-lights, injectors, steam-gauges, oil-cups, and other parts supplied by firms who make a specialty of manufacturing those parts. The same process has gone on in every department of engineering, and will undoubtedly continue.

But while this subdivision is going on, there are influences at work which bring about organization of these divided arts for the accomplishment of definite and common ends. This is shown by the various associations which have been formed of railroad officers and companies, through which they may be able to agree upon such joint action as may be required to promote the objects for which railroads are intended. Similar organizations, which represent other engineering and industrial interests, are increasing rapidly, and undoubtedly will have a very great influence in the future on all branches of engineering, but especially on the operation of railroads. The need of united action and of agreement became obvious very early in their history, and is every year becoming more urgent. When disconnected lines were built in South Carolina, Maryland, Massachusetts, and Ohio, the importance of a uniform gauge did not appear, and then, as now, engineers

seemed to be ambitious to impress their opinions and personality on their work by doing each something different from the other. When the lines were joined the absolute necessity of a uniform gauge became imperative, and at great cost they were made to conform to each other. With the progress and interchange of traffic the need of uniformity in time, in the construction of parts of cars, signals, rules for operating roads, keeping accounts, etc., etc., have made themselves felt, and now every year brings up some question for consideration and action. Various associations have been formed, such as the Master Mechanics', the Car-Builders', the Roadmasters', the Passenger Agents', etc., which take action on matters relating to special departments of railroad operation. These associations act independently of each other to a very great extent, and, quite naturally, the question of their relations to each other has been brought up recently. At the meeting of the General Time Convention, held in October, a resolution was adopted to appoint a committee of five to take up the matter of the relation of all national associations of railroad officials to the Time Convention. Messrs. Charles E. Pugh, Pennsylvania Railroad ; C. W. Bradley, West Shore ; R. H. Soule, New York, Lake Erie & Western ; I. R. Kendrick, Old Colony ; W. W. Peabody, Baltimore & Ohio, were appointed such a committee.

The question is therefore fairly launched for consideration by the Time Convention, and will, no doubt, come up at the next meeting. Some preliminary discussion of the subject will then not be out of place or untimely.

It may be said that thus far no very distinct scheme of organization has been proposed. The Time Convention is a name which does not indicate that the association to which it belongs is composed of railroad companies, and that the representatives of those companies are usually the general managers or general superintendents. The members, therefore, outrank those of the other associations. That fact, then, raises the question whether, if any system of organization or consolidation is adopted, the other associations will occupy a subordinate relation to the Time Convention, or whether they shall have co-ordinate rank and authority somewhat like that of a house of representatives to a senate, or whether the various associations should be consolidated, and then be divided into sections, somewhat like the American Association for the Advancement of Science or the British Association ; the different sections being devoted to the consideration of separate classes of subjects, such as locomotives, cars, road-bed, passenger and freight traffic, accounts, etc.

With any form of organization the question will present itself whether concurrent action of what is now called the Time Convention and the other associations should be required in case any direct relation is established between them. That is, should all measures of importance originating in the various associations be referred to the Time Convention for approval before being finally adopted ? The danger of that would be that it might retard all action to such an extent as to make it impossible or very difficult to do anything.

It should be pointed out that the rules of the Car-Builders' Association require that the adoption of all standards shall be referred to a letter-ballot for decision. This practically brings the most important action of that association before the general managers and general superintendents for revision, because their representatives, it may be supposed, would consult their managers or superintendents before voting. A very simple way of bringing about what has been suggested would be to refer all matters of importance to the Time Convention, to be submitted to letter-ballot by that body. Such measures would be discussed by the Time Convention, and, possibly, referred back to the association in which they originated, with recommendations for amendment. Measures which were first brought up in the Time Convention which relate to cars would naturally be referred to the Car-Builders' Association, or, if they related to locomotives, to the Master Mechanics', and similarly with action relating to other departments. After being discussed and modified, possibly, they would go back to the Time Convention for final submission to letter-ballot.

A very simple amendment to the constitutions of the different associations and the appointment, possibly, of committees of conference, is all that would probably be required to bring about the co-operation that has been outlined. Whether such co-operation would be desirable may be considered an open question. As a preliminary to any action the name of the Time Convention should be changed. The "American Railroad Union" has been proposed instead, and is, perhaps, as good a title as could be suggested.

The constitution of the Time Convention says that "memberships shall be by companies, . . . which may be represented by their President, Vice-President, General Manager, and General Superintendent, or by any official or officials connected with the transportation or traffic department."

The danger is that the officers named will not be able or disposed to give the time to the meetings which will be required to act intelligently on such subjects as would come before them if direct relations were established with the other associations. It would seem to be a better plan to allow the President, General Manager, or General Superintendent to appoint a representative member in the association, as is now the practice in the Master Car-Builders' Association. If they are not able to attend the meeting themselves such officers could select the ablest persons on their staffs to represent their companies.

The whole subject is a very important one, and worthy of full discussion.

THE INTERNATIONAL RAILROAD CONGRESS.

THE International Congress of Railroads, which recently closed a second and very successful meeting at Milan, in Italy, its first session having been held at Brussels in 1885, is an association for which we have no exact parallel in this country. It had its origin, we believe, in a meeting held to arrange a convention or treaty for regulating the exchange of traffic between the railroads of the different European countries, but at the Brussels meeting an organization was completed and the Congress developed into an association for the discussion of questions relating to the construction and operation of railroads. It was then decided to make the association permanent, and to hold meetings every other year, an invitation being issued to all European countries to send delegates. The second meeting was held, as mentioned above, at Milan, in October last, and the third is appointed to be held in Paris, in October, 1889.

The association or Congress has no fixed individual membership, but is composed of delegates named by the railroad authorities of the several countries. As in most European countries the Government either owns all or part of the railroads, or at any rate exercises a strict control over them, in most cases the delegates were sent directly by the Governments of their respective countries. At the Milan meeting all the states of Continental Europe were represented except Russia. There was a delegation from England also, which was strong in its composition in one respect, as it included several railroad men of high standing, but weak in another respect, for few or none of its members were able to take part in the discussions, which were conducted in French, which has been established as the official language of the Congress. Outside of Europe two delegates came from the Argentine Republic and one from Mexico. No railroad men from the United States took part in the conference, although two or three were present as spectators.

The membership of the Congress is not limited to any class of railroad officers, and it is expected that all branches of the service will be represented. The discussions covered a wide range of subjects, and in order that they may be properly dealt with the members are divided into sections, each dealing with a certain class of subjects, as construction, maintenance of way, motive power, rolling stock, management of passenger traffic, etc., etc. Each question, after its discussion by its separate section, is submitted to the full Congress for general debate.

The discussions, however, are not on questions brought up at random. Under the present arrangement the Congress at each meeting selects a list of subjects for the next meeting; under each subject a number of questions are prepared to which the different railroad managements are requested to send answers. A permanent Commission is appointed, whose duty is to publish the proceedings of the Congress and to prepare for the next meeting by collecting and formulating the answers received to the questions, and by preparing or procuring papers or monographs on the designated subjects. This permanent Commission publishes the information thus collected for distribution in advance of the next meeting, so that delegates may come to the sessions fully prepared to discuss the subjects in hand.

In all this, it will be seen, the routine does not greatly differ from that of our own railroad associations, the Commission taking the place of the special committees to which subjects are referred by our Master Mechanics' or Master Car-Builders' Associations. Without disparaging the work done by those and other associations, it must be admitted that the International Congress has the advantage in the more careful previous preparation of subjects, while the publication of reports and papers before the meeting is a practice worth imitating.

In another respect the International Congress resembles our associations. Its decisions are simply recommendations, having the weight which full discussion by experts would naturally give, but no binding force upon the members. As a natural result, we find that those decisions are given with some reservation, the members being, apparently, reluctant to lay down positive rules which they may be afterward required to break in their official capacities and under orders of their superiors, whether the ruling authority be a ministry of public works or a board of directors. This absence of positive authority, however, while it weakens the force of the decisions, does not lessen the advantages derived from discussion and from exchange of ideas and comparison of experiences.

The subjects discussed at the Milan meeting of the Congress and the decisions reached, may be briefly summed up as follows:

In the section of road-bed and track six leading questions were submitted. As to the first, the use of metallic ties, the Congress repeated substantially the decision made at Brussels, that this question must be decided by local circumstances affecting the relative cost of metallic and wooden ties. As to the comparative cost of maintenance, further experience is needed to decide.

On the question of material for bridges, steel of proper quality was recommended, especially for spans of exceptional length. It is pointed out, however, that where steel is used special care in manufacture and testing is necessary.

The fourth question was as to the policy of letting out the maintenance of way by contract. On this point the decision was unfavorable to the contract system.

As to precautions against snow, no general rules were recommended, as local circumstances differ so widely.

For roads of exceptionally heavy traffic the recommendations made amounted simply to this, that the best material should be used and great care taken to keep road-bed and track in good condition.

The section of motive power and rolling stock discussed plans for the best utilization of locomotives, but did not recommend any special plan. For passenger rolling stock the balancing of wheels, the use of better springs, and the greatest possible reduction of weight consistent with strength were recommended.

As to the construction of locomotives, the section held that there was nothing new as to material. The system of concentrating repair work at the principal shops of a road, leaving only light repairs to be made at division shops, was considered the most economical. More care in selection of oils and in keeping axle-boxes properly supplied was urged. The system of premiums for locomotive engineers and firemen was thought to be economical and productive of good results. Further experiments with compound locomotives and with the use of steam or water-jets in place of sand was recommended.

The application of continuous brakes to freight trains was not considered practicable at present, owing to the wide differences in construction of rolling stock in different countries.

The only remaining question before this section related to the lighting and heating of trains. For lighting, gas was highly recommended, but further experiments with electricity were considered desirable. The question of heating was left an open one, and further experiments were called for. Steam heating does not seem to have been considered. Owing to the difference in construction of European cars and the general system of dividing them into small compartments, the heating question there presents some difficulties with which we are not familiar. The car-stove, however, is not yet a burning question there.

The third section, on management, discussed the running of passenger trains, the regulation of passengers—a more important question there than here, where passengers usually regulate themselves—the management of

freight traffic, lines of light traffic, switching and yard service, and the lighting of stations.

The fourth section, on general questions, discussed the employment of women in railroad service; payment of employés; institutions for insuring employés; taxes on railroad property; international relations, and technical publications and statistics.

The fifth section was a special one, devoted to the consideration of questions relating to secondary (branch or feeder) lines. Such lines are now exciting much interest all over Europe, and their construction and organization are regarded as of much importance. The discussions of this section took a wide range, covering construction, rolling stock, management of traffic and stations, and many other points. Most of these were left open for further information, and will be considered at the next meeting.

The very brief summary which space has permitted will show how much ground the proceedings of the Congress cover, and something also of its methods. While the proceedings were characterized by more of the French fondness for routine and formula than would be altogether acceptable here, there were many points which are worth study and, perhaps, imitation, on this side of the water.

NEW PUBLICATIONS.

THE VOSBURG TUNNEL: BY LEO VON ROSENBERG. New York; published (by permission of the Lehigh Valley Railroad Company) by the Author.

Great as have been the changes in all departments of railroad engineering during the past few years, the advance in the art of excavating tunnels has probably been more considerable than in any other branch. Mr. Drinker's work on tunnelling, complete and exhaustive as it was at the time of its publication, already needs supplementing on account of the rapid advances made in the improvement of drilling machinery and the use of new explosives. For these reasons a monograph on tunnelling, like the present one, must always be of interest to all engineers who desire to keep themselves informed in this direction.

The Vosburg tunnel on the Lehigh Valley road is the latest of the great railroad tunnels in this country to reach completion. It is, perhaps, a sign of the advance in the art that the work was undertaken and carried through, not because it was indispensable to the building of the road, but to shorten and improve the alignment of a railroad already several years in operation. At the point where the tunnel was built the original line of the road followed the banks of the North Branch of the Susquehanna around a sharp bend, and the tunnel was built to dispense with the use of a section of road full of sharp curves and difficult to maintain, by substituting a shorter and more direct line leading through, instead of around, the mountain.

The author of this book, Mr. Von Rosenberg, was employed as an assistant in the construction of the tunnel, and had free access to all the drawings and records made by the engineers during the progress of the work. He has made use of his opportunities, as the many illustrations accompanying the work show. These illustrations, with the accompanying text, enable the reader to understand clearly the methods employed in the tunnel, the difficulties encountered, and the varying progress made in different sections of the tunnel.

The book is one of a class which is very useful, but not as large as it ought to be, for nearly all our readers who are engineers know how difficult it often is to find a good description of many of the great works, the records of which are hidden away in the archives of railroad companies, or at the best are to be found only in incomplete form in the transactions of some society.

COMPETING ROUTE MAPS. Chicago and New York; Rand, McNally & Co., publishers.

It has always been a difficult matter for the ordinary traveler and shipper to lay down or to get in his mind accurately the competing routes between the more important points in the country. To pick out the different lines on an ordinary map requires more knowledge of railroad geography than most men who are not specialists in the matter possess; and they are generally reduced to a reliance upon the so-called maps issued by the railroad agents, in which the agent's own road is always represented by a straight line, while the other fellow's runs all around the map and has any number of crooks and turns. The maps in question supply this want by showing the lines as they actually are, each being taken from a correct map of the section of the country between the two points covered. They are small enough in size to be folded and carried in the pocket, and are very clear, the lines being shown in different colors, while the map is not complicated by the introduction of an unnecessary number of small stations. The different roads are shown without fear or favor, and one can see at a glance which line is the most direct and which reaches the more important points by the way.

The maps of this series include the competing lines between such points as New York and Chicago; Chicago and St. Louis; Chicago and St. Paul; Chicago and Omaha; others will be issued until all the important through lines are included. They are of uniform size, and one or more can be arranged in a case as desired.

Nothing in this line more convenient to a large number of people has been issued for some time, and these maps should have a large circulation.

BOOKS RECEIVED.

UNITED STATES GEOLOGICAL SURVEY: GEOLOGY AND MINING INDUSTRY OF LEADVILLE, COLORADO: BY SAMUEL FRANKLIN EMMONS. Washington; Government Printing Office. This is Monograph No. XII of the series issued by the United States Geological Survey, and is a volume of 750 pages, containing an exhaustive account of the subjects of which it treats. It is accompanied by an atlas with maps of Central Colorado, the Leadville District, etc., executed in the admirable style in which all the work of the Geological Survey is done.

REPORT OF THE INTERSTATE COMMERCE COMMISSION: 1887. Washington; Government Printing Office.

IMPORTS AND EXPORTS OF THE UNITED STATES FOR THE YEAR ENDING JUNE 30, 1887: PREPARED UNDER THE DIRECTION OF THE CHIEF OF THE BUREAU OF STATISTICS. Washington; Government Printing Office.

IRON TRADE REVIEW AND WESTERN MACHINIST. Cleveland, Ohio. Messrs. Day & Carter, heretofore publishers of the journal named above, have transferred their entire business to the Cleveland Printing and Publishing

Company, a corporation duly chartered under the laws of Ohio, with an authorized capital stock of $50,000. The officers of the company are: W. M. Day, President; F. N. Carter, Secretary; F. J. Staral, Treasurer; A. Wintemberg, Superintendent. Mr. Day will have editorial supervision of the company's various publications.

THE MARTIN CAR-HEATING SYSTEM. Dunkirk, N. Y.; issued by the Martin Anti-fire Car-Heater Company. This is a very full and carefully illustrated description of the Martin system of steam heating, the smallest details being so described that no one can fail to understand them.

THE TRUE NATURE AND DEFINITION OF INSANITY: BY C. H. HUGHES, M.D., LECTURER ON NEUROLOGY, ST. LOUIS MEDICAL COLLEGE. St. Louis; reprinted from the *Alienist and Neurologist.*

THE OVERHEAD CONDUCTOR ELECTRIC RAILWAY COMPANY. Pittsburgh, Pa.; issued by the Company. This book contains a short article on electric motors for street railroads, followed by an illustrated description of the Finney system of overhead conductors and motors.

THE RAILWAY SERVICE GAZETTE, an excellent paper published at Toledo, O., and devoted to the interests of railroad employés, has bought and consolidated with itself the *Railroad Track Journal*, a monthly paper which has been for some time published, and which was addressed chiefly to section foremen and trackmen.

THE WALDUMER ELECTRIC BRAKE. Cincinnati, O., issued by the Waldumer Electric Brake Company. This pamphlet contains a description of the Waldumer electric brake, and a report made to the Ohio Commissioner of Railroads on some tests of the brake made on the Cincinnati, Washington & Baltimore Railroad in September last.

Contributions.

The Heating of Railroad Cars.

To the Editor of the Railroad and Engineering Journal:

I NOTICE in the December number of the ENGINEERING JOURNAL an article on the Heating of Railroad Cars by H. Q. Hawley. The writer assumes (and I think correctly) that steam from the engine will be generally used, and adds: "The matter most requiring to be tested for the solution of this problem is how to supplement steam from the engine for the time when it cannot be used, before the cars are connected with it, and when it is disabled away from terminal points. . . . Why, then, are the tests now being made confined to the former one, while for the latter use nothing is done, although without providing for it the question cannot be settled?" Further along, after enumerating facts in relation to various means for heating now relied on, and assuming that the methods described for heating when the engine is not available are not practical, he concludes that the problem of car heating is narrowed down to the inquiry, "Can gas be used for it?"

I will state that this company is making tests in that direction. Our cars are being heated by steam from the engine. We have a small upright boiler in each car which receives hot water and live steam from the engine. Under the boiler is a gas-burner, which is lit when the engine is detached from the car. The gas is contained in a tank underneath the car, and is used also for illuminating. We have raised steam in the boiler from cold water in 23 minutes. We are meeting with most gratifying results. The entire apparatus is simple, easily managed, and cheap.

We are using it on our Belleville accommodation train. The cars are detached from the engine at the Relay Depot, East St. Louis, go across the bridge to the Union Depot in St. Louis, and return to the Relay Depot, being detached from the engine from 45 to 70 minutes, often without any reduction of the temperature in the car, and never to an uncomfortable degree. We have had no very cold weather so far this season, but expect by spring to be able to give facts and figures that will demonstrate a practical solution of the Car Heating Problem by proving that steam from the engine and compressed gas under the car will furnish the means for the safest and most economical way of heating passenger cars.

C. H. SHARMAN,
General Superintendent Illinois & St. Louis R.R.

SOME SUGGESTIONS ABOUT BRAKES.

To the Editor of the Railroad and Engineering Journal:

I HAVE read with deep interest the accounts of the triumphal progress of the new Westinghouse brake, and have high admiration for the qualities of mind which enabled a man to overcome so promptly and successfully grave mechanical difficulties in the way in which it was done by the inventor of that brake; but the sentiment which I have seen expressed in the words "the automatic air-brake has been made perfect," is not, to my mind, fully justified.

Mechanical contrivances, at their best, like men and some other things at theirs, are a good way behind perfection.

As nearly as I can judge, counting the cars to weigh 24,000 lbs. each, and the locomotives to have been modern eight-wheelers, the train weighed in the vicinity of 775 tons. This immense weight was stopped from a speed of 40 miles per hour, on level track, in about 580 ft.—truly a wonderful performance in the light of what has been common practice.

In considering this and the other results, however, it should, of course, be borne in mind that they indicate what may be attained under similar conditions, the most important condition being, perhaps, that the train shall consist of empty cars. Now, this is a condition not always easy to be filled. Moreover, it is sometimes less important to protect the cars than to protect their contents. Moreover, a train of empty cars cannot cause as much destruction to a train which it may meet too suddenly as a train of loaded cars might cause.

Suppose, for instance, that the train of 50 cars above referred to had contained the full loads which they were built to carry—that is, 60,000 lbs. each—then the train would have been 1,500 tons heavier, or approximately three times as heavy, and according to a simple rule of arithmetic, it would have required nearly three times as great a distance in which to stop the train, or, in the special case above referred to, nearly one third of a mile, instead of 580 ft. When the loaded train had moved 580 ft. after the instant application of the brakes, it would still

have a speed of about 32 miles per hour, and would possess more than twice as much destructive force as the empty train would when running at speed without any application of brakes.

The experiments have shown in what distance trains can be and ought to be stopped in cases of emergency, but from the fact that brake pressure is adjusted to the empty car, and is independent of the load, the published results are liable to convey an incorrect impression.

Each pound of load should have its percentage of braking effect as well as each pound of car. This seems to be easy to accomplish, and will probably be the next important improvement in power-brakes for freight trains. I say freight trains, because there is not the same necessity in the case of passenger trains, where the load is so small a fraction of the total weight. This matter has not, therefore, until the present agitation in relation to power freight-brakes, been fairly before the railroad world; but how can it fail to be considered now, when the important matter of the adoption of a standard freight-brake is, or seems to be, so near at hand, and when heavier loads are demanded and lighter cars may well be desired?

Before indicating a simple, and what appears to be a practicable, method of arranging the brakes to act on the load as well as on the cars, I would like to call attention to another seemingly desirable feature in brakes.

It is, of course, possible to apply the automatic air-brake with full effect only when the pressure in the main and auxiliary reservoirs is fully up to working pressure. In a train of 50 cars the cubic contents of these reservoirs amounts to about 21 times the contents of the main reservoir.

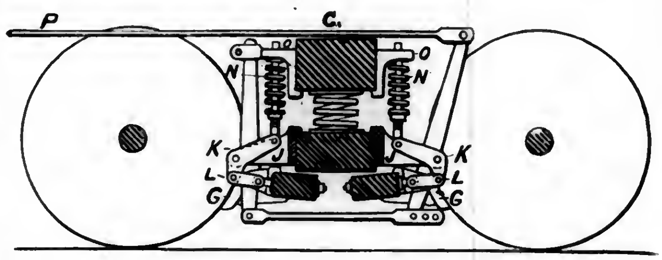
It is very possible for a train to start out from a station without having this large quantity of air up to pressure ready for an emergency. Accidents have often occurred with passenger trains on this account. Freight trains, which must carry so much greater volume of air, will be more liable to them.

Would it not, then, be a great advantage if the brakes were so contrived that it would be impossible for a train to start until the air-pressure is fully great enough for the emergency? In other words, would not a brake be more perfectly and safely automatic which—other things being equal—would hold the train at rest until full brake-pressure was provided for an emergency stop?

The principle may as well be extended to hand-brakes. Would it not be safer for the brakeman, as well as for the train or car, if the labor involved in applying the brake could be done while the car is at rest, and the power thus stored merely released when required?

I am aware that the application of springs to brakes, which shall hold them on until they are wound off by hand or otherwise, is an ancient idea, but elements of impracticability have appeared in methods heretofore brought out or tried. The principle, however, appeals to the reason, and there really seems to be no great obstacle in the way of applying it successfully to practice.

The figure herewith is a section of a freight-car truck, in which the unusual or added parts are: *J J*, brackets attached to the spring-planks, and carrying bent levers *K K*; *L L*, links connecting levers to brake beams; *N N*, compression springs, abutting against brackets *O O* attached to the truck-bolster. These springs are arranged, as will be seen, to force the brake-shoes *G G* against their wheels, and are adjustable. It will also be seen that pulling on the brake-rod *P* draws the brake off, against the action of the springs, instead of applying it. The levers *K* are bent to such angles, and the springs *N* made to such specifications, that the pressure of brake-shoes against wheels will be practically constant within the limits of wear of the brake-shoes. There are two or more



springs to each brake-beam. The apparent advantages of such a construction as this are manifold.

First. The springs may be so adjusted that the pressure of brakes on wheels is exactly that pressure which will give the best effect without a possibility of sliding the wheels on ordinary track. The importance of this matter is well understood.

Second. The bolster *C* is depressed and the springs *N* therefore compressed by an increase of load. The pressure of brakes is therefore greater the greater the load. The importance of this feature is hereinbefore discussed.

Third. No triple-valve or auxiliary reservoir is required—only the air-cylinder to hold the brakes off.

Escape of air, through parting of the train or otherwise, will set the brakes on the whole train, and cars with this brake may run in trains with the present automatic air-brake. Moreover, failure of any brake connection will set the brakes on that car.

Fourth. The brakes cannot be released, and therefore the train cannot be started, until the air-pressure throughout the train is up to full working pressure. Gradual applications may be made quite the same as heretofore.

Fifth. The hand-brake, being used to draw brakes off, may be constructed with such leverage that the work may be done with freedom and ease, and since the power will be generally stored while the train or car is at rest, there will be less danger to brakemen.

Sixth. The method of action of this brake is shown on its surface. It has no complicated feature hard to be understood by men who lack mechanical training.

Seventh. The instant of time required to operate a triple-valve or other intermediate mechanism is saved, therefore the application of brakes throughout a long train may be more nearly simultaneous than with other brakes. Perhaps this feature should have been referred to first, not last.

This statement of advantages is, of course, in the nature of speculative philosophy until the matter shall be put to the test, and thereafter will be in the stage of experimental mechanics until it shall be found to be practically successful; but, curiously enough, up to the last few weeks freight train-brakes, as a whole, have been in the experimental stage; in fact, is any system out of it yet?

The beginning of all advance is thought, or theoretical consideration, as some are pleased to express it. I submit that the theories here set forth seem to rest on good premises.

A. K. MANSFIELD.

280 Broadway, New York.

THE PRINCIPLES OF RAILROAD LOCATION.

BY PROFESSOR C. D. JAMESON.

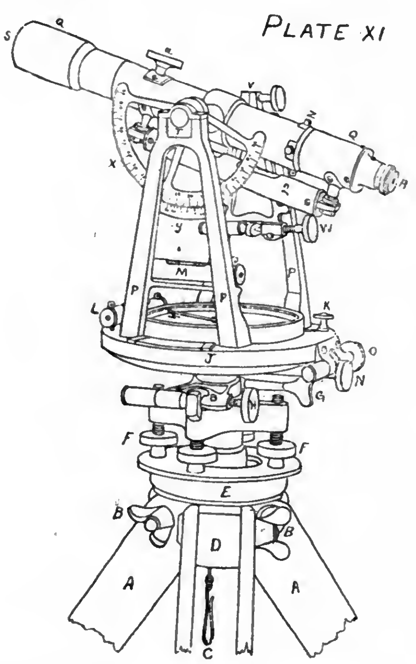
(*Continued from page 551, Vol. LXI.*)

CHAPTER V.

OTHER INSTRUMENTS USED IN LOCATION.

THE ENGINEER'S TRANSIT, as built by the different makers, varies to some extent in the details, but the general principles are the same in all, and the type shown in Plate XI may be taken as a typical instrument.

In this plate *A A* are the legs of the tripod; *B B* the thumb-screws by means of which the legs are made fast to the lugs *D* on the tripod-head *E*; *C* is a hook suspended from the center of the instrument, and upon which the plumb-bob is hung. *F F* are the levelling screws, four in



number, by means of which the upper part of the instrument is brought to a level. (On some instruments there are only three levelling screws.)

G is the clamping-screw by means of which the lower plate of the instrument is clamped. *H* is the tangent-screw by means of which a slight but steady revolving motion is given to the instrument after it has been clamped by *G*. At *J* there are two horizontal plates circular in shape and turning on the same center, but separately.

The upper plate of these two has on it two vernier scales at opposite sides of the plate. The lower or bottom plate is divided off into degrees and half degrees. By means of these divisions and the verniers on the upper or top plate, an angle can be read to minutes on the ordinary transit, and on some extra ones to 20 seconds.

K is the screw which works the lever by means of which the magnetic needle of the compass is raised or lowered on its pivot. *L* is one of the two spirit-levels (the other one, *M*, being at right angles to it) by means of which it is known when the instrument is level.

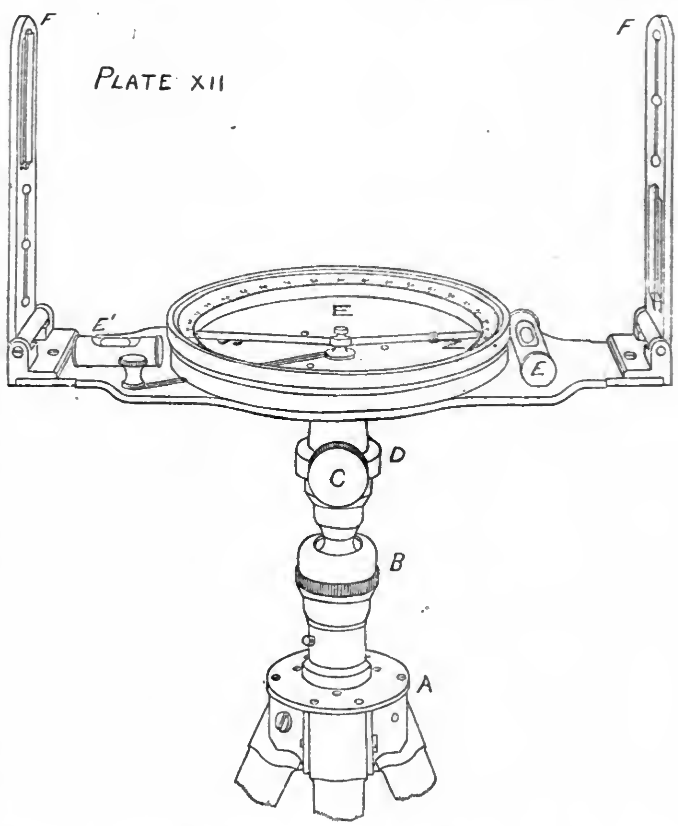
N is the screw for clamping the two plates together, and *O* is the tangent-screw by which the upper plate can be moved slightly but steadily.

P P are the uprights or standards which hold the telescope.

Q Q is the telescope which is held in the uprights at *T*, and can be revolved at will around *T* as a center. *R* is the eye-piece and *S* the object-end of the telescope; *U* is a milled-headed screw by means of which the object-glass is moved back and forth until the object to be looked at can be seen with perfect clearness, or, in other words, is focussed. *V* is the screw for clamping the telescope, and *W* is the tangent-screw for moving the telescope slightly but steadily after it is clamped. *X* is part of the arc of a circle, divided into degrees and half degrees, and is used for measuring vertical angles. *Y* is the vernier scale with which to read the arc *X*. *Z Z* are the screw-heads which hold the rings holding the cross-hairs.

In the telescope are two hairs, one vertical and the other horizontal, whose point of intersection is in the line of collimation of the telescope. When stadia work is to be done with the transit there are also the stadia wires in the telescope. These stadia wires are two horizontal wires at equal distances each side of the center; they are put in immediately behind the cross-hairs. *Q* is a long bubble tube fastened to the telescope and parallel to it. By means of this tube levels can be run with the transit. The upper part of the instrument takes off just above the tangent-screw *H*, and then the lower part unscrews from the tripod at *E*.

The SURVEYOR'S COMPASS, Plate XII, differs from the Pocket Compass already described (Chapter IV) only in the two following points: It is larger, usually having a 5-in. compass-box, and it is mounted on a tripod. *A* is the tripod to which the compass-box is connected by the ball-and-socket joint *B*, by means of which it is levelled. The compass-box sets into the top of the tripod at *D*, and



is held in place by the screw *C*. *E* and *E*' are the bubbles which show when the compass-box is level. The sights *F F* shut down over the compass-box, and when the

screw *C* is loosened the box can be lifted off the tripod and put in a case for carrying.

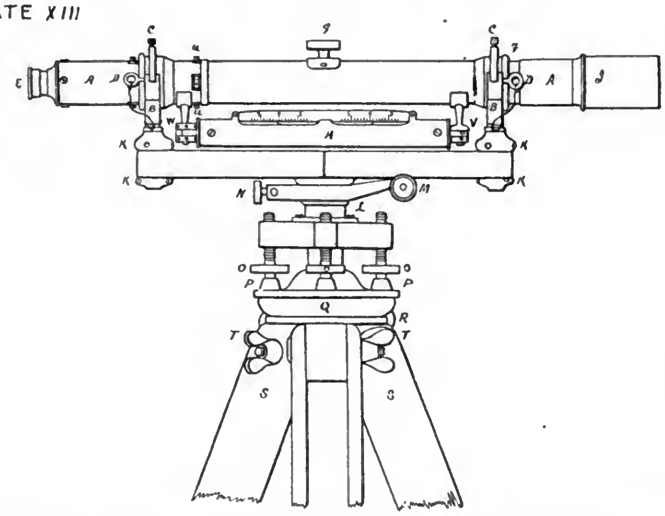
In using the Surveyor's Compass it is set up over any point desired, the position being determined by means of the plumb-bob. The screw *C* having been loosened and the compass-box brought to a level by the hands, the screw *C* is made tight. The instrument is then sighted through *F F* at any desired point, the magnetic needle loosened, and the bearing of the line taken. The direction of the lines being taken by their magnetic bearing, no "back-sights" are used. But apart from this, the method of using the Surveyor's Compass on railroad work is the same as that described for the use of the transit. As will be seen, under certain circumstances the compass is preferable to the transit.

The one thing to guard against is the presence of any metal, such as a knife or bunch of keys, which might disturb the needle by its magnetic attraction.

The WYE LEVEL, as made by different makers, varies in some of its details, but the general principles are the same in all, and all are much like, in details, the one shown in Plate XIII.

In this plate *A A* is the telescope which rests on the two wyes *B B*. The two clamps *C C* shut down over the telescope, and are held in place by the two pins *D D*, which are fastened to the instrument by means of small pieces of

PLATE XIII



cord. *E* is the eye-piece of the telescope, and *F* is the slide of the object-glass. *G* is a milled screw by means of which the object-glass is moved back and forth. *H* is a long spirit-level suspended from the telescope and parallel to it, by means of which the instrument is known to be level. *I* is a small brass tube covered with a dead black on the inside, which is put on the large end of the telescope to protect it from the rays of the sun. *K K K K* are capstan-headed screws by means of which the wyes are raised or lowered. The telescope swings freely upon the joint *L*. *N* is a clamp by means of which the telescope can be clamped in any horizontal position, and thus prevented from moving in any direction except by use of the tangent-screw *M*; by means of this screw the telescope can be moved very slightly to the right or left. *O O O* are levelling screws. There are four of these in ordinary instruments, but only three in some of the more modern ones. *P P* are small cups in which rest the ends of the levelling screws. *Q* is the main plate of the instrument, which screws on to the plate *R*. This plate *R* is fastened to the tripod *S S*, which consists of three wooden legs, painted and shod with metal. *T T* are thumb-screws by means of which any wear in the legs of the tripod where they join the head is taken up, thus preventing all unsteadiness from slack.

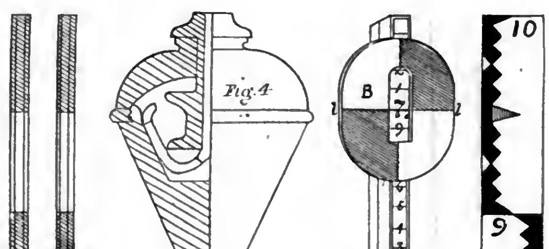
In the telescope of the level are two cross-hairs made of the finest spider web or fine platinum wire. One of these hairs is vertical and the other horizontal. These cross hairs are fastened to metal rings on the inside of the telescope. The capstan-headed screws *U U* are made fast to this ring, and by means of these screws the hairs can be moved in order to adjust them.

The telescope *A A* turns with ease in the wyes, and as it is necessary to have the bubble *H* always directly below the center line of the telescope, it is a good plan to get the bubble once in its proper place, and then make a scratch running from the telescope upon the wye; then no time will be lost in being sure the telescope is in its proper position, as it only has to be turned until the two ends of the scratch come together.

On some of the more modern instruments there is a little projection on the wye, and a corresponding one on the telescope, and when these two are in contact the telescope is in its proper position. In the center of the tripod-head is a chain and hook, upon which a plumb-bob may be hung when needed.

Two LINING RODS are shown in Plate XIV, fig. 1; they are such as are used with either a transit or a surveyor's

PLATE XIV



compass. They are round or octagonal in shape, and from 6 to 10 ft. long, 1 in. or 1¼ in. in diameter at the bottom, and ½ in. or ¾ in. in diameter at the top. They are divided into feet, the foot-spaces being painted red and white

alternately. At the bottom the rods are shod with a steel shoe about 1 ft. long. These rods are made of white pine or any light suitable wood. Under some circumstances they are made of small gas-pipe, but if over 6 ft. long these are too heavy for convenience.

The STANDARD LEVEL ROD is shown in Plate XIV, fig. 2. It is divided into feet, and these again into tenths of a foot. For convenience in use the rod is made in two parts, the back part sliding upon the front, as shown. The two parts are clamped together by means of a milled-head screw. The target *B* is quartered red and white, and is made to slide up and down on the rod. When the rod is closed the target is clamped in any position by means of a screw on the back of the rod, which does not show in the drawing. Under ordinary circumstances the target is not used, as the leveller can read to hundredths of a foot through the telescope. But on "Bench-marks" and "Turning Points," or any points where greater accuracy is required, the use of the target is necessary. When the reading to be taken does not require that the rod should be extended the target is moved up or down the rod until the line *l l* coincides with the horizontal hair in the telescope, and is then clamped. At the side of the opening in the target is a small brass vernier scale, the zero of which is on the line *l l*. By means of this scale the elevation of the target can be read to thousandths of a foot. When the level sets so high that it is necessary to extend the rod, then the target is clamped with the line *l l* on the line 7, and the back of the rod is raised or lowered until *l l* coincides with the horizontal hair in the telescope. Then the rod is clamped and the elevation read from the side by means of a brass vernier scale fastened on in the proper place.

Besides the level rod just described there is used a great deal in railroad work a rod similar to that shown in Plate XIV, fig. 3, which consists simply of a rod 10 ft. long, divided into feet and tenths of a foot in such a manner as to be plainly visible at a long distance.

The rod first described is more convenient for the rodman to carry, and where the leveller has not had much experience it is the better rod to use, as the work must go on more slowly, and when the target is used there is less chance for error. With an experienced leveller, however, work can be done with the second rod much faster and with perfect accuracy.

The PLUMB-BOB, as shown in Plate XIV, fig. 4, is the ordinary plumb-bob; it is used with the transit, the surveyor's compass, and sometimes with the level. It consists of a brass weight, the point of which is sometimes of steel. In the top is a hole, through which runs a cord, and the plumb-bob is suspended by this cord from the hook *C* of the transit (Plate XI). It then hangs precisely on the center line or vertical axis of the instrument, and by means of it the instrument can be set up exactly over any desired point.

The SURVEYOR'S CHAIN is shown in Plate XIV, fig. 5, where part of the chain is represented. Where feet are the standard of measurement, the chain is 100 ft. long. Where meters are used, the chain is usually 20 meters long.

A is the handle of the chain, and the measurements are taken to the outside of this handle. At the point *C* of the handle is a hole through which passes the end *B* of the first link of the chain. This end *B* has a screw thread cut on it and a nut on the inside of the handle, by means of which the chain can be made slightly longer or shorter, in order to correct any error which may be found when the length of the chain is tested.

The long links of the chain are connected by two short links placed between each pair of long links. The object of using the short link is to avoid the liability of the chain catching and kinking. The length of the links is 1 ft. (in a 100-ft. chain) from *A* to *E*.

At each 10 ft. on the chain there is a brass tag. Ten feet from each end the tag has the shape shown at *F*—that is, it has one point. Twenty feet from each end the tag has the shape *G*—that is, two points, and for 30 ft. three points, and so on to the middle of the chain, where the tag is round, like that shown at *H*.

These chains are made either of steel or iron. The steel ones are much lighter, but in a rough country are liable to be broken, as the links will not bend, but snap if caught on a stump or rock, while the iron ones will bend, and can be straightened with a hatchet.

This may be called the first adjustment of the chain. In straightening the links do not strike directly on the link with the hatchet, but put a piece of wood between the hatchet and the link.

The second adjustment of the chain is, after it is perfectly straight, to test its length with a steel ribbon or any other standard of length.

MEASURING PINS, shown in Plate XIV, figs. 6 and 7, are made of steel and are from 12 in. to 18 in. long. Fig. 7 shows one kind, which has a weight, *w*, near its point, the object being to make the pin, when held by the top and dropped, fall vertically.

When stakes are used the pins are not used. But very often a line has to be run and measured where permanent marking on the ground is not necessary, and in this case the pins are very convenient. Their principal use is to keep an accurate count of the number of stations gone over. There are 11 pins in a set. One is put in the ground where the chaining starts, and then the head chainman puts one in at the end of each chain, and the rear chainman picks them up as he comes along. When the head chainman has put in his last pin that marks station 10, he leaves that pin in, and taking the other 10 from the rear chainman, proceeds as before. Thus the pins serve not only to keep account of the distance gone over, but also to mark the end of each chain, thereby showing the chainman where to hold the rear end of the chain. It is a good plan to tie a piece of red flannel on the top of each pin, so that it may be seen the more easily.

The BOARD ROD is shown in Plate XV, fig. 1; it is used with the clinometer in cross-sectioning. It consists of a ¾-in. board 6 in. wide and 6 or 8 ft. long, painted white, and divided into feet for convenience in measuring. The hole *A* is cut in it for convenience in carrying.

The CLINOMETER, shown in Plate XV, fig. 2, is used in cross-sectioning with the Board Rod. It consists of the bottom part *A B*, fastened to which is the movable arm *C*, which turns on the pivot at *D*. This arm has the bubble *O* fastened to the side and parallel to it. *E T* is a circular arc, the center of which is *D*; this arc is of brass, and has the different angles marked on it from zero up to 90°.

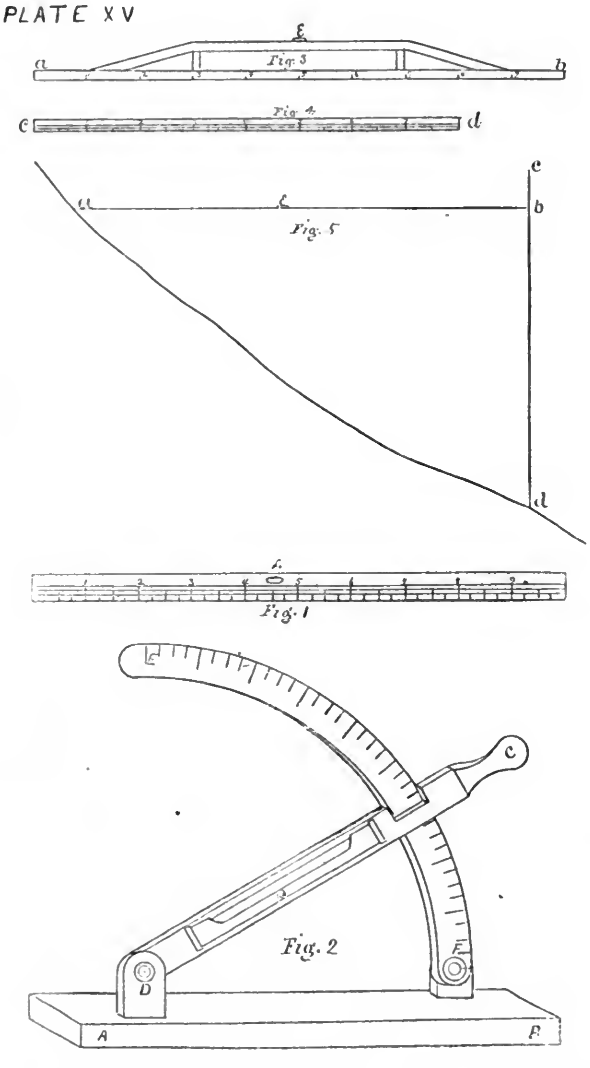
The manner of use is as follows: The Board Rod is laid on the ground on its edge and the Clinometer placed on it. Then the movable arm *C* is raised until the bubble is in the center and the angle is read from the scale *E F*.

This angle shows the inclination of the Board Rod, and consequently the surface of the ground, with the horizontal.

The CROSS SECTION ROD is shown in Plate XV, figs. 3 and 4, in two forms. The first one, *a b*, is a rod 10 ft. long, bound with brass at both ends. It is better made in the shape shown than as a simple rod, as the bracing prevents any warping or twisting. At *e* is a spirit-level set parallel to the rod. In some rods there are two bubbles, one at each end, in the place of the one at the center, *e*. The second rod is simply a square wooden rod about 6 ft. long and divided into feet and tenths. The lower end should be bound with metal. A short level rod is sometimes used in the place of this second rod.

The manner of use is as follows: One end of the first rod is put at the starting point (Plate XV, fig. 5), *a*, and then the rod is brought to a level, one end resting on the

PLATE XV



ground. The second rod is then used to measure the distance from the other end, *b*, of the rod to the ground. Having thus the two measurements, the length of the first rod and the distance, *b d*, measured by the second rod, we have the slope of the surface of the ground.

The STADIA ROD is shown in Plate XIV, fig. 3, which gives a typical form of this rod. It is of wood, 3 or 4 in. wide, and ¾ in. thick. It is divided usually into feet and tenths of a foot in such a manner that the divisions can be very easily seen. Whether it is divided into feet or not depends upon the distance apart of the stadia wires in the telescope, but it should always be so divided that one long division on the rod shall be exactly intercepted by the stadia hairs when the rod is held one chain from the instrument, or, rather, from the focussing point.

CHAPTER VI.

ADJUSTMENTS OF AN ENGINEER'S TRANSIT.

There are five adjustments to an Engineer's Transit (Plate XI), as follows:

1. To adjust the bubble-tubes *L* and *M* parallel to the vernier plate.
2. To adjust the standards *P P* to the same height.
3. To adjust the cross hairs so that one is vertical and the other horizontal.
4. To adjust the vertical hair so that it is in the line of collimation.
5. To adjust the long bubble-tube 2.

1. To adjust the bubble-tubes *L* and *M* parallel to the vernier plate: By means of the levelling screws *F*, bring the bubble of each tube to the center, with the instrument in one position. Then turn the instrument one-half round, and if the bubbles go off the center bring them half-way back by means of the capstan-headed screws on each tube, and correct the other half of the error by means of the levelling screws *F*. Repeat this until the bubbles will stay in the center while the instrument is revolved in any direction.

2. To adjust the standards to the same height: This should be done before the instrument leaves the maker's hands, but this is not always the case. Level the instrument and sight the intersection of the cross-hairs upon some high point, such as the top of a steeple. Then lower the object end of the telescope and find some other point (drive a stake, if necessary) that is cut by the intersection of the cross-hairs. Then unclamp the upper plate and turn the instrument half around. Then sight the intersection again on the high point, and bring it down to the lower point, and if the intersection strikes the lower point, the standards are all right; but if it does not strike the lower point, then, by means of the screws at the top of the standards, correct one-fourth of the error and repeat the trial, moving the lower point each time until the adjustment is perfect.

3. To adjust the cross-hairs so that when the instrument is level one is vertical and the other horizontal: The cross-hairs are fastened upon the metal ring at exactly right angles with each other, so that if one of them is vertical the other will be horizontal. When the first and second adjustments have been made, level the instrument and sight the vertical hair upon a cord held in a vertical position by a plumb-bob, and if the hair coincides with the plumb-line it is in adjustment. When it does not so coincide two opposite screws at *Z* should be loosened and their heads tapped gently with a knife, until the hair does coincide with the plumb-line. The hair is then vertical, and the other hair will be of necessity horizontal.

4. To adjust the vertical hair so that it is in the line of collimation: Set up the instrument and level it, then sight upon a chain-pin set at a point some distance away; reverse the telescope, and put in another pin on the line of sight. Unclamp the instrument at *G*, and revolve it until the cross-hairs again cut the first point; then reverse the telescope again, and if the cross-hair still cuts the second point, then it is in the line of collimation, and the three points taken (the transit and the two pins) are in one straight line. But if on removing the telescope the second

time the cross-hair does not cut the second point, put a pin in where it does cut, measure the distance between this and the second pin, and put another pin in at one-half the distance; then put in another at a point half-way between the second and third pins, loosen the screws at *Z*, and move the ring until the hair cuts this last point. Then tighten the screws and repeat the operation until, upon reversing the instrument twice, the sights all come in the same straight line. After making the fourth adjustment, see that the third one is all right.

5. To adjust the long bubble-tube *Q*: In doing this we first place the telescope exactly horizontal, and then bring the bubble-tube exactly parallel to it. The manner of proceeding is as follows: Drive two stakes into the ground, and with the level bring the tops of these stakes to exactly the same height. Set the transit in a line with these two stakes, level it, and take the reading on the level-rod held on top of each of these stakes. Then by trial move up and down the telescope, and also the target on the level-rod until we have at last reached the point where the reading on the level-rod is the same on both stakes. When this is so, clamp the telescope and test the reading. The telescope is then exactly horizontal. If the bubble in the long bubble-tube is then in the center, this tube is parallel to the telescope. If the bubble-tube does not stand in the center of the tube, then, by means of the capstan-heads, the end of the tube can be raised or lowered as may be required, and by this means the bubble brought to the center. While the telescope is still clamped in this horizontal position it is always a good plan to examine the vernier of the vertical circle and see if it stands at zero. If not, by means of the screws on each side of this, the one being loosened and the other tightened, the vernier can be slipped until the zero of the vernier corresponds with the zero on the vertical circle.

In case there is no level convenient by means of which to bring the tops of the two stakes to an exact level, this can be done by means of the transit, as it makes no difference whether the telescope is horizontal or not. Set the transit up firmly and bring it to a level; then, with the telescope approximately horizontal, measure off a certain distance from the transit, say 300 ft., and drive a stake. Take the reading with the level-rod from the top of this stake through the telescope, then unclamp the two plates of the transit, revolve the upper plate 180°, measure off exactly the same distance from the transit, and drive a stake until the level-rod held on the top of it gives the same reading as on the top of the first stake. Then, although the telescope of the transit is not necessarily horizontal, the tops of these stakes must be absolutely upon the same level, provided proper care has been taken in measuring the equal distances on each side of the transit.

CHAPTER VII.

ADJUSTMENTS OF THE WYE LEVEL.

The adjustments of the Wye Level are all very simple, and only need care and practice. Much care must be taken not to strain any of the screws by using too much force. When for any reason a screw does not turn easily, find out what the reason is and remedy it.

Before making any adjustments, screw the eye-glass well home, and make a scratch on the edge of the frame, so that at any time one can by examining see at once whether the eye-glass is in exactly the same position, because if this is not so it will be no use to adjust the instrument.

There are three adjustments to the level.

1. The adjustment of the cross-hairs. To see that their point of intersection shall strike the same point on a distant body all the time while the telescope is being turned an entire revolution in the wyes. This is called the *line of collimation*.

2. The adjustment of the bubble-tube *H*, to place it parallel to the line of collimation.

3. The adjustment of the wyes by which the telescope and long bubble-tube are supported, so that the bubble-tube and line of collimation shall be at right angles to the vertical axis of the instrument, and remain horizontal while sights are being taken on various points.

1. Adjustment of the cross-hairs: Set up the instrument firmly on the ground. In this adjustment it is not necessary to level the instrument, but it should be approximately level. Pull out the eye-piece *E* until the cross-hairs are plainly visible. Then sight the instrument upon some distant point, or better, upon a vertical line, such as the cord of a plumb-bob. By means of the milled-head screw *G* move the object-glass until the point can be plainly seen or brought to a focus. In focussing an object the object-glass is the only one that must be moved. The eye-glass should only be moved to focus the cross-hairs, and then not touched. Clamp the instrument with *N*, and by means of the tangent-screw *M* set one of the cross-hairs exactly on the point or line. The clips *C C* having been opened, the telescope is then, without any jar, gently revolved one-half. If, then, upon sighting through the telescope, the hair still coincides with the point, that hair is in adjustment, and we proceed to examine the other hair. But if it does not coincide we then, by means of the screws, move the ring which holds the hair in the opposite direction from what *appears* to be the right direction, and as near as can be judged by the eye, one-half the distance that the hair is off the point. Turn the telescope back to its first position, and by means of the clamp and tangent-screw set the hair again on the point and again revolve the telescope. If necessary, move the ring again, and so on until the hair is in perfect adjustment. Then proceed with the other hair in the same way, and when both are in perfect adjustment their intersection will strike exactly the same point while the telescope is turned entirely around.

2. Placing the long bubble tube parallel to the line of collimation: In this there are two separate adjustments, one horizontal by means of the screws at the end *W*, and one vertical by means of the two vertical nuts at the end *V*. To make the vertical adjustment, turn the telescope until it is over two of the levelling screws that are diagonal, and clamp it, and open the clips *C C*. Bring the bubble to the center of the tube by the levelling screws. Lift the telescope gently out of the wyes, turn it end for end, and put back in the wyes. Then if the bubble is still on the center, it is in adjustment; but when the bubble is off the center, bring it half-way back by means of the screws at *V*, by either raising or lowering the end. Bring the bubble back the other half of the error by means of the levelling screws, and lift out the telescope and reverse it the same as before. Repeat this operation until the bubble remains exactly in the center when the telescope is reversed in the wyes. To make the horizontal adjustment, bring the telescope over two diagonal levelling screws and clamp it; then bring the bubble to the center by means of the levelling screws, taking care that the bubble is directly

under the telescope. When the bubble is in the center, turn the telescope slowly to one side in the wyes, about ¼ in., and watch the bubble. If it goes off the center it must be brought half-way back by means of the screws at the end *W*, then the telescope turned back so that the bubble comes directly under it, and the bubble brought to the center again. This must be repeated until the bubble stays on the center when the telescope is turned in the wyes and when it is under the telescope.

3. To make the height of the wyes such that the line of collimation is at right angles with the vertical axis of the instrument: Turn the telescope over two diagonal levelling screws, but do not clamp it; bring the bubble to the center, then swing the upper part of the instrument half round, so that it stands end for end over the same two screws. If the bubble is still on the center the wyes are in adjustment, but if the bubble goes off the center it must be brought half back by means of the screws *k k*, and the other half by means of the levelling screws. This must be repeated until the bubble stays on the center when the instrument is swung round.

(TO BE CONTINUED.)

THE MILLER PLATFORM AND COUPLER PATENTS.

(*Continued from page* 452, *Vol. LXI.*)

WE come now to the discussion of the Miller 1866 patent, and the questions involved are very complex. To the mechanic who has thoroughly mastered the Janney system as used upon the Pennsylvania Railroad cars the matter may be clear, but without such a mastery of the subject the following explanation will not be of much avail so far as making the matter clear is concerned.

In the case of the 1866 patent, as in the case of the 1865 patent, two claims were said to be infringed, the *first* and the *third*. The first claim related to the system of trussing the platform, as shown in the Miller patent. This claim, though evidence was taken by both sides in regard to it, was abandoned by the complainant's counsel toward the close of the case. This was done probably because in the course of the testimony it became evident that the Pennsylvania Railroad cars did not have the system of trussing described by Miller, and that what the defendants did have could not be called an equivalent for what Miller claimed.

Miller claimed four trusses; the defendants had two trusses (so called by the complainants) and two horizontal stay-rods. Thus the defendants sustained their platforms by a mechanism substantially different from the mechanism described and claimed by Miller. As in the case of the first claim of the 1865 patent, the first claim of the 1866 patent was abandoned likewise, and therefore it will be needless to go into this subject in detail, for to do so would require extensive diagrams and much explanation.

Turning now to the third claim of the 1866 patent, which was considered by both sides as the most important, we find it reads as follows:

3d. The construction of spring-buffers and couplings, substantially as herein described, to produce compression between cars which are coupled together, so that the spring-buffers and couplings shall constantly act together to prevent shocks and jerks in starting, stopping, or running trains, said buffers and couplings being arranged substantially as set forth.

It was understood by both sides that what this claim meant was as follows: Coupling cars so that their couplers should have pressure on their draw-faces or surfaces to hold the cars together, while the buffer or buffers should be exerting their pressure to force the cars apart. The action of the buffers to separate the cars being resisted by the couplers at their draw-faces, the whole being thus put under the influence of two strains, one given by the buffer-springs to separate the cars, and the other a result of the action of the buffer-springs transmitted to the couplers to keep the cars together.

Now, Miller was not the first person by any means who thought that it would be a good thing to subject the cars to the double strain of buffers and couplers, each operating in its own direction.

This method of coupling cars had for many years, and since the earliest days of railroading, been the common method abroad. Indeed, all cars in England and on the Continent are coupled by devices which put the cars under exactly the same conditions of strain as Miller claims. However, the foreign cars arrive at the desired end by different methods, and just here is the point where Miller devised something said to be new. In the foreign cars the coupling is usually first effected by a link, and then the attendant by means of a screw proceeds to so shorten the link as to put the buffers into compression, which compression placed upon the buffers necessitates a strain upon the drawing or active surfaces of the coupling mechanism. But this result is reached usually in the foreign cars by the manual operation of an attendant, while in the case of Miller the result is reached by using the power of the engine, which compresses the buffer-springs, and by the use of automatic couplers, which, when the buffers are properly compressed, couples the cars automatically.

In this way and by these appliances Miller saves the services of the attendant to screw up the coupling link, and by using the power of the engine and the instantaneous action of an automatic coupler, makes a coupling which, when effected, gives the desired strains to the cars, and does not require manual exertion to effect. However, the condition reached is not a new condition for the cars to be under, for all foreign cars are under precisely the same conditions of strain, only it is usually arrived at in a different way. Therefore, what is left of novelty for Miller to claim is his supposed new way of arriving at the desired condition of strain.

Therefore, the first thing necessary to an understanding of the matter is to ascertain just what Miller showed in his 1866 patent. In this patent a draw-hook having at its rear end a draw-spring projects from each end of each car. Above this hook and in the buffer-beam a buffer is located having at the rear of its shank a buffer-spring. Now, the buffer-face is so arranged that when the car is not coupled to another car, but stands in its normal condition, the buffer-face is out beyond the draw-face of the hook, say 2 in. more or less. This is the normal condition of the parts when the cars are not coupled. Suppose that this car is now to be coupled to another like car, as the engine drives the cars together the buffers first meet and the buffer-springs are compressed, and this continues till the draw-faces of the respective hooks interlock, when the coupling is completed. In this condition the compressed buffer-springs must react against something, and they do react against the springs of the draw-hooks, in this way loosing some of their compression and transferring it to the draw-hook springs, which, in their turn, are com-

pressed to the extent of the expansive power of the buffer-springs. The cars are now forced apart by the buffer-springs, and are held together by the draw-hooks and their springs, both sets of springs being under compression.

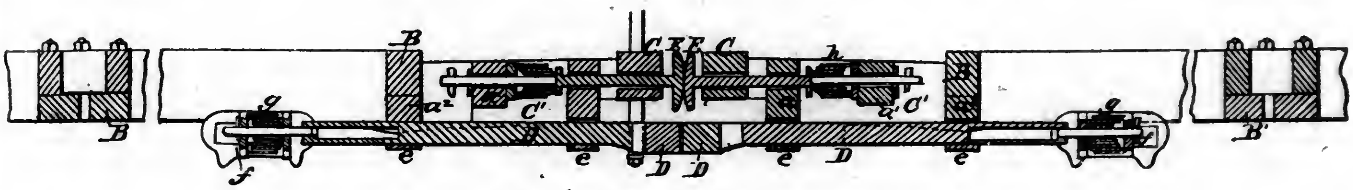
This condition of strain is the same as all European cars are subjected to, but in the case of Miller it is obtained by the force of the engine, which, operating in connection with automatic couplers, saves the trouble and expense of a man to screw up the coupling links, for with the Miller system, when the right amount of compression in the buffer-springs has been had, the couplers automatically interlock, and the work of an attendant is avoided or dispensed with.

Let us now see what Miller showed in his patent.

The cut given herewith is a longitudinal vertical section, showing the abutting ends of two cars. *D D* are the hooked draw-bars, *E E* the buffer-faces, *C C* the buffer-beams. It will be noticed that the buffers are shown as

As a matter of fact, in the cars of the Pennsylvania Railroad, as constructed during the life of the Miller patent, it was not intended that the side buffers should be under compression when the cars were coupled and standing at rest. By reason of the yoke mechanism used with the Janney system, it was intended that the side buffers should only come into play and co-act with the opposing buffers when the coupler-head was moved inward or outward, and clearly this was a condition of affairs never contemplated by Miller, for in his structure when the draw-springs were under the most forcible compression in running his buffer-springs were under the least compression, and *vice versa*.

Miller never contemplated making his couplings other than couplings; they never were to act as buffers, and could not so act. Now, in the Janney system as used on the Pennsylvania Railroad cars, the coupler-head was the most efficient buffer used, and by the connection of the



THE MILLER PLATFORM AND COUPLER.

Longitudinal Section.

slightly compressed or forced inward, their faces being pressed together by the buffer-springs *h*. This pressure finds its way to the draw-bar springs *g g*, which are also slightly compressed, or upon which a compressing force is exerted. *B B* in the cut represents one of the bolster-beams located near the end of each of the cars.

Miller in his patent says as follows:

> Another object of my invention is to prevent the sudden and injurious jerks and concussions of cars in stopping or starting a train by the employment of centrally arranged spring couplings and buffers, in such manner that these parts are under constant tension or compression when the cars are coupled together, and the buffer-heads are brought in contact with each other, thus forming a continuous connection of all the cars in a train, as will be hereinafter described.

After this Miller describes the details of his structure, but the above fairly sets forth the spirit of his mechanism. It will be needless to here describe the details of the Janney coupler as used by the Pennsylvania Railroad, as this mechanism has been fully described in a previous article relating to this case.

The first difference between the mechanisms that suggests itself is this: In the Miller mechanism the strain of the buffer-springs when the car is coupled and at rest has to pass through the woodwork of the car before it reaches the coupler-springs. In the Janney mechanism this strain never leaves the coupler and buffer mechanisms, which form a distinct device bolted to the car, but having the strains confined to the mechanism itself, without passing the same through the woodwork of the car.

In the Miller mechanism the buffing is central, and this feature is dwelt upon by Miller as a distinct point of advantage, while in the Janney structure the buffing is done by two side buffers in part, but principally by the draw-heads, which are themselves buffers, and, in fact, do most of the work of buffing. In the Miller structure none of the buffing action can be done by the hooks.

coupler to the buffers the motion of the former was sent to the latter, but always in such a way as to cause protrusion of the buffers; thus all the springs were put under compression together or were released together. By the yoke mechanism the strain of buffing in the Janney system as used on the Pennsylvania Railroad cars, whether this strain was taken by the side buffers or by the coupler, was always transmitted to a point below the floor timbers of the car. In the Miller structure, on the other hand, this strain was always sent back in line with the floor timbers of the car, and this feature of the structure is probably essential with Miller.

Pages could be written relating to the mechanical differences of the two structures, but it seems rather useless to follow the subject up in this connection. The reason is this: In the trial of the case all the questions discussed as to the 1866 patent were left undetermined, so far as the court or jury went, and though testimony was taken regarding the patent, the removal of the case by the court from the jury on the grounds previously stated obviated any necessity for a determination of the questions of invention, infringement, or anticipation.

The case was tried by Mr. S. D. Cozzens for the complainant, and he had Mr. E. S. Renwick as an expert. For the defence Mr. Edmund Wetmore, of New York, and Mr. Andrew McCallum (counsel for the Eastern Railroad Association) appeared, and they had Mr. H. L. Brevoort, of New York, as an expert.

Since the above was written it has been said that a suit under the Miller 1865 and 1866 patents is to be pressed against the Pittsburgh, Fort Wayne & Chicago Railroad. This road uses a somewhat different arrangement of coupler and buffers from these described, having, it is true, the Janney system, but without the yoke lever used by the Pennsylvania Railroad. It is said that a somewhat new state of facts will appear in this case.

PATENT CLAIMS.

By Emil Starek.

Experience confirms the fact that the time in which a patent can be secured depends largely upon the ability of the applicant to state clearly and properly the claim covering his invention.

In his attempt to "set forth the precise invention for which a patent is solicited," the applicant is beset with difficulties which only the experienced practitioner can readily surmount; and, although general suggestions as to how to state the claims are found throughout books on patents, and in the decisions of the Commissioner and the courts, the writer has attempted in the present communication to offer a *résumé* of such suggestions, which, it is hoped, may be of service to inventors and patent solicitors.

Inasmuch as the embodiment of any idea is only capable of ocular demonstration through the medium of a material device, or in the realization of changes (physical or chemical) in a body from the operations of such device upon said body, it follows that all inventions can be divided into (1) Inventions in *Structure*, comprising (*a*) mechanical construction and (*b*) composition (either physical or chemical), and (2) Inventions in *Method* or *process*. Inventions of the second class, although dealing purely with abstract elements, require the assistance of material elements for their realization. Under mechanical construction and composition an example is unnecessary. An interpretation of the meaning of process (or method) would, however, be facilitated by an example: In the patent law meaning, a method or process is "an operation performed by rule, to produce a result by means not solely mechanical;" *e.g.*, a claim for "the mixing of crude India-rubber with sulphur, and then subjecting the mixture to a high degree of heat," would be a process claim; and, in accordance with the principle above enunciated, the realization of the process is only manifest through the medium of material elements co-operating to effect the desired result.

I shall now venture to offer such suggestions regarding the drawing up of claims as are the outcome of corrections and recurring amendments to improper claims daily presented to the patent examiner; and that the suggestions herein offered may be fully *en rapport* with the practice of the Patent Office, I shall avail myself of the most recent decisions by the Office, and in the selection of definitions of certain terms set forth therein.

A machine is a contrivance by means of which a force applied at one point is made to produce an effect at some other point. The very definition of a machine carries with it the idea of transmission, and the transformation or modification of the power so applied. To accomplish either, whether the result of the power applied be constant or variable, it is evident that some inter-relations between the different parts of the machine must and do exist; and that the relation which one element of the machine bears to its neighbor is communicated throughout the entire train of mechanism. Let us take, for example, a locomotive engine. It is manifest that if we remove the connecting-rod, or the piston-rod, the engine becomes inoperative. Again, if we vary the cut-off, or the lead, or shift the point of release, we secure variable results in the action of the engine. Before the removal of the connecting-rod or the piston-rod the engine of the locomotive presented an operative device or machine, every element of which so co-operated with every other, and whose inter-relations were such as to be capable of the transmission and variation of the power applied as implied in the definition. Prior to the removal of the parts referred to, the locomotive presented what, in the patent meaning, is termed an "operative or complete combination." Now, an operative combination does not necessarily imply or necessitate *motion* between the elements of the combination, as would be the case of a train of mechanism driven by steam or other motive power. The elements of such a combination may be stationary, but at the same time hold communicative relation with each other; *e.g.*, the flues joining two smoke-drums in a hot-air furnace. A removal of the flues would result in an incomplete combination. To use the language of the Honorable Commissioner, "considered as a generic term a combination may be defined to be a union of mechanical elements involving such a co-ordination of individual functions as to constitute a common function. Co-ordination necessarily implies some modification of the individual function of each part as it existed prior to the combination." "To be patentable a combination must conform to the requirements of the definition. . . ." The above definition will, no doubt, serve to distinguish claims for mere aggregations. An aggregation may be defined as an assemblage of elements so placed that the action or function of one in no wise affects the action or function of any other element in the same assemblage or aggroupment; each performing its function as if the others did not exist; so that the removal of any one of them would leave the remaining ones in precisely the same condition as they were before such removal.

There are, however, two very important intermediate phases between a combination proper and an aggregation, sufficiently well defined to receive consideration in this connection. (1) Two devices may be so constructed as to possess two features (structural) in common. On combining such devices the two structural features may be made to blend into *one*, subserving in that position a duplicate function. When so combined, although the action of the one device in no wise affects that of the other, separation of the one from the other is precluded by the relation of the feature alluded to as blended and now essential simultaneously to both. Although such a combination does not involve co-ordination of function, and is neither an aggregation proper, as the two devices can be separated by simply restoring the common element now blended, it follows that a claim covering such a *pseudomorphic* (if such a word be allowable) combination can only, with propriety, be drawn to the specific construction of the resulting device. (2) This phase refers to a combination of elements so related that, although their combined co-operation produces a result properly termed unitary, an element may be removed from the combination in its entirety without destroying the operation of the remaining elements, but simply altering or reducing their functional capacity.

Inasmuch as the drawing of claims for methods (or processes) and the combination phases above referred to are attended with no serious difficulties, and as such claims are in the minority in the course of patent practice, we shall at once proceed to the consideration of true combination claims. It is essential, and *en rapport* with the practice of the Patent Office, that, as expressed in frequent decisions, a claim should clearly define the combination

intended to be covered by the invention. This is by no means an easy matter.

In cases where a specific combination constitutes only an improvement of the device of which it forms an essential element, applicant frequently introduces said device in the introductory form of a phrase, for purposes (1) to definitely locate such combination, and (2) to introduce inferentially that term in the phrase to which the improvement belongs, as an element of the combination covering the improvement; *e.g.*, "In a car-heater, the combination with," or "in a hot-air furnace, the combination with," etc. Unless the combination cited after the introductory phrase be complete in itself, the claim citing such cannot be regarded as citing a legitimate combination, and should not be allowed. The requirement that a claim shall define the combination intended to be covered by the invention is, in practice, either wrongly interpreted or misunderstood. Now, the true aim in defining a thing is to settle the thing in its compass and extent. A definition of a word in the dictionary would be very unsatisfactory if we were obliged to look up its derivation or origin for a perfect understanding of its meaning; or, in the case of a compound word, look up the definitions of the individual words forming it. A combination claim may be favorably compared to a compound word, and should be so defined as not to necessitate reference to the specification for its disclosure. Furthermore, like a compound word whose definition depends upon the limitations which one of its components puts upon the meaning of the others, so, a claim can only be satisfactorily defined when the relation and the co-operation between the different elements composing it are clearly set forth; and this can only be accomplished by including each element as a positive component and not by simple inference. Again, whatever relation an element may occupy in a working combination, that element is always characterized by the function or functions peculiar to itself; but it is also true that these functions might characterize a vast number of other elements, differing structurally, perhaps, and yet capable of being substituted in the mechanism. So that it is obvious that a combination cannot be well defined by a statement, wholly or in part, of the functions of the elements composing it.

It is frequently the case that an element of a combination is introduced as a link in the chain of mechanism covered by the invention, which link does not constitute an element of the invention, but is essential to its operation. Such a link is usually introduced by the words "means for" or "mechanism for," followed by a participle indicative of its function. Such "means for" or "mechanism for" may be *any* means, and which are not intended to express any patentable difference over the prior state of the art. When such an expression as "means for" or "mechanism for" is introduced and signifies intermediate relation between two contiguous elements, the claim at once becomes complete as a *patentable* combination, and also as a *mechanical* combination. Sometimes, however, the "means" referred to do not hold an intermediate position between the adjacent or contiguous elements of an operative device, but may hold a terminal position with respect to a combination which, of course, must be complete as a patentable combination. In such a case the "means for" may be omitted from the claim altogether; when omitted the remaining combination will be complete in the patentable sense (since the patentability does not depend on the "means for"), and, when added, the combination will be complete both in the *patentable* and *mechanical* sense. It is, of course, obvious that to add the "means for" in such a case would only be a superfluous and unnecessary addition to the language used in describing the combination which establishes its patentability.

When the number of elements of a mechanically complete combination are few, and their relations are such that the "means for" or "mechanism for," not determining its patentability, can be omitted in accordance with the principle just enunciated, it frequently happens that the remaining elements may be so reduced, *numerically*, as to present no longer a "combination," but only a single element, either simple or compound, or, to use a mathematical expression, the number of terms of the combination has reached the *inferior limit*. Such a device, although by itself inoperative, can be claimed *per se* in view of the functional features it possesses over any prior device in the same line, and on which it may be an improvement; or, from its nature, may be claimed as an "article of manufacture." Applicants, however, very often make their claims too fragmentary in their attempts at "inferior limits" in cases where such limits are wholly inapplicable, and so claim a device suggestive of no special function over the prior state of the art; *e.g.*, an applicant may claim, "In a car-heater, the steam-pipe *a* leading from the locomotive through the cars, etc." There is still another error to which applicants are liable, and which is a matter of considerable importance, and that is, claiming the *whole*, with parts of itself, or with intangible elements, such as holes, openings, and the like, which are but structural features, and not mechanical elements susceptible of combination.

Since the conception of a material object is formed from its definition in the mind "by bringing any given object (or impression) into the same class with any number of other objects (or impressions) by means of some characters common to them all," it follows that the object so conceived becomes a generic type for any or all such objects as may possess some characteristic peculiar only to themselves. In the matter of claims, where the combination presented is of such a nature as to admit of illustration by more than one specific construction, it is permissible to have a generic claim, and under the rules one specific claim, to illustrate such genus. A method or process claim cannot be made specific to any generic claim; and this results from the peculiar nature of the elements composing it. A claim for a method recites the successive steps involved in that method, and any addition to, subtraction from, or variation of, such steps would involve a change in the method or process, which process would not be regarded as specific under the former process considered as generic, but would constitute a claim for a different method or process.

The ordinary rules employed in drawing combination claims should be observed (with the necessary modifications and omissions) under method or process claims.

Although the subject of claims is by no means exhausted in the present communication, it is thought that the foundation rules upon which claims are to be built have been laid down; and in their observance much time will, no doubt, be saved by both applicant and examiner, and thus insure speedy issue.

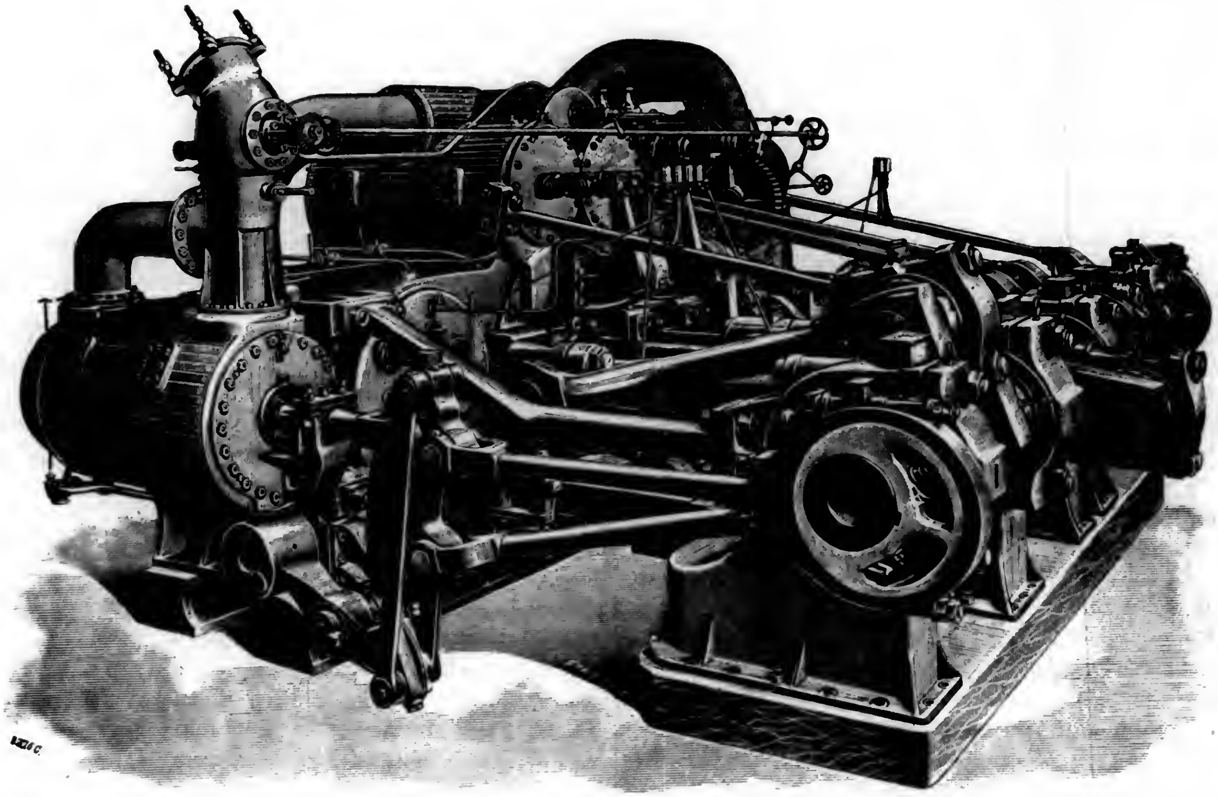


Fig. 1.

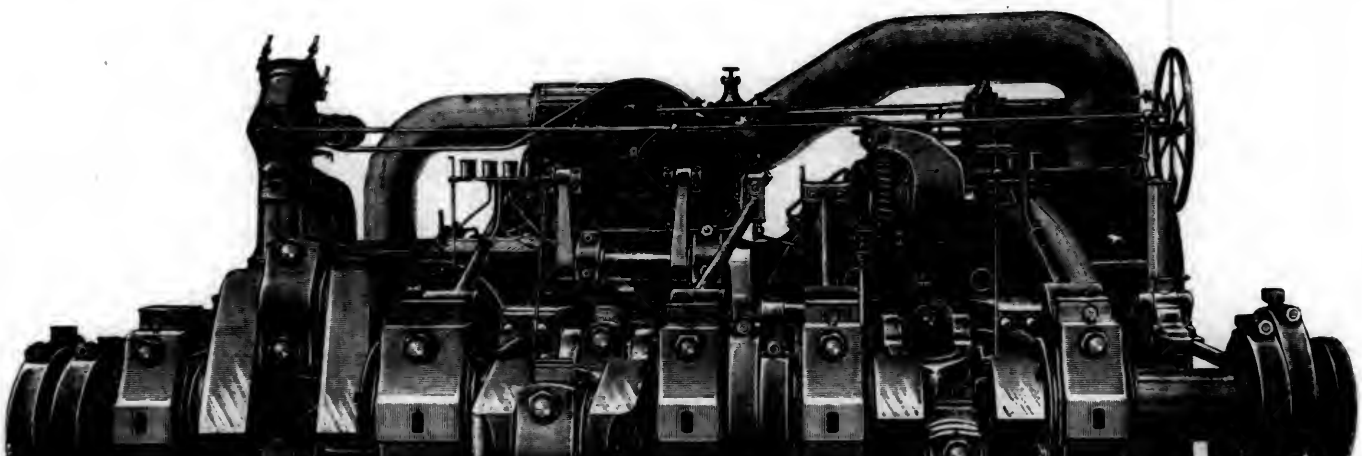


Fig. 2.

TRIPLE-EXPANSION ENGINES OF CRUISER "ORLANDO" FOR THE BRITISH NAVY.

Wire Gauges.

[Abstract of paper read before the American Society of Civil Engineers, by S. S. Wheeler, Jr.]

THE author presented with this paper a chart showing the different wire gauges now in use, and stated that there is no serious fault in some of the existing gauges ; the sole difficulty is because so many gauges are in use there is confusion. The cause of this multiplicity and confusion is briefly as follows :

1. The names of the early gauges were confused, the names of makers and of towns being used indiscriminately, and each gauge being known sometimes by one name and sometimes by another.

2. The lack of an authoritative standard and accurate tools for duplicating caused the copies made by different firms to differ among themselves.

3. A large variety of new gauges of almost every possible nature have been promulgated within comparatively recent years by the men who have worked and written on the subject, as members of committees and individually.

The first two causes of confusion were more or less natural in the evolution of wire gauges, and may be considered unavoidable. The third, the introduction of new gauges, is going on at the present day, and ought to be stopped.

The result of there being no law of formation of these gauges is that among the English gauges there are more than a dozen Birmingham and many "Old English," "Old London," "Warringtons," etc., giving different values for the same number, between gauges of the same name, simply because each maker, having no fixed relation between the sizes to go by, copied some old pattern which was inaccurate from wear. The existence of this nebula of irregular old gauges is the chief cause of the unintelligent outcry against gauges. There is none of that variation between copies of either the Brown & Sharpe or the Latimer-Clark, both built upon a fixed rule.

Of the 31 existing gauges, the American, or Brown & Sharpe, the one by which copper, brass, gold, etc. (all wires except iron and steel), are measured in America, is the only one that exactly fills the requirements considered. It is a perfect parbolic curve, with a uniform reduction of 11 per cent. between consecutive sizes. The only other gauge which approaches it in the two leading requirements, a range of sizes which covers the wants of wire-users without useless intermediate sizes, and regularity of increase of the sizes, is the Latimer-Clark proposed standard. But this has not been much used, is unfamiliar, and has not been extended in sizes finer than No. 22 American gauge.

The proposition frequently brought out, that the micrometer should be used exclusively, indicates that there is a widespread failure to realize what the wire-makers want. The majority of manufacturers have neither the time, skill, nor need for the micrometer. They want a rough notch gauge adapted to sorting out the sizes which they draw, and as simple and as easy to read as possible. There is no use in recommending or condemning the micrometer. It is used, and, notwithstanding any condemnation, will continue to be used in all accurate work, as it is indispensable.

THE ENGINES OF A NEW BRITISH WAR-SHIP.

THE accompanying engravings (taken from the London *Engineering*) represent the engines of the belted cruisers *Orlando* and *Undaunted*, which were built for the British Government by Palmer's Shipbuilding & Iron Company, Limited, at Jarrow, England. The ships and engines were finished and delivered to the Admiralty last summer, and their performance so far has been very satisfactory.

These vessels, as above stated, are of the belted cruiser class, and are exactly alike ; they were designed by the Admiralty. They are each 300 ft. long, 56 ft. broad, and of 5,000 tons displacement. Their deep-water draft, with all guns, stores, ammunition, coal, and crew on board, is 20 ft. forward and 22 ft. aft.

The engines were designed by the makers, and are of the horizontal type. There is a complete set of triple-expansion engines to each screw, the dimensions of the cylinders being 36 in., 52 in., and 78 in. diameter, respectively, and 42-in. stroke. There are two independent engine-rooms, divided by a transverse bulkhead stretching across the vessel. The shaft of the forward engine is thus considerably longer than that of the after engine, under the condensers of which it passes.

The framing of the engines is of steel, the main bearings and the cylinders being connected by forgings, as shown in fig. 1. The eccentrics for the high-pressure cylinder, and also those for the low-pressure cylinder, work directly on to the respective valve-spindles through the links. The eccentrics for the intermediate cylinder stand on the shaft between two bearings (as shown in fig. 2) and actuate a rocking shaft, the two upper arms of which work the valve-spindles. The reversing shaft is placed under the slide-bars, as shown in fig. 1, and is operated by a link coupled to a crank-pin in a worm-wheel and worm, the reversing engines being coupled to the shaft of the worm. These reversing engines are placed on top of the low-pressure cylinder. The valves of the high-pressure cylinder are piston valves, and those of the intermediate cylinder are of the same type.

The condensers have 12,000 square feet of cooling surface, and the condensing water is circulated by two centrifugal pumping engines to each set of main engines.

The propellers are each 14 ft. 6 in. in diameter by 18 ft. 9 in. pitch. There are four boilers, each 14 ft. 6 in. in diameter by 16 ft. 6 in. long. Each has six corrugated furnaces, 3 ft. 8 in. in external diameter. The total grate surface in the four boilers is 540 square feet, and the total heating surface 16,055 square feet. The maximum pressure is 130 lbs. per square inch.

The results of the forced draft trials of the *Orlando*, which took place on April 19 last, were as follows : Steam in boilers, 129 lbs.; indicated H.P., starboard engine, 4,313 ; port engine, 4,309 ; total indicated H.P., 8,622. The highest H.P. attained during the four hours' trial was 4,992, or 492 above what was contracted for, and the vessel attained a mean speed, by patent log, of 19¼ knots. This was, at the time, the highest speed yet attained by any armed vessel of the British Navy. On this trial the engines worked remarkably well, and the boilers gave ample steam without priming. The air pressure used in the stokeholds averaged 1¼ in. of water. On the natural draft trials on April 13, a speed of 17.25 knots was obtained with 5,617 H.P. during a four hours' run, the maximum H.P. being 5,856, or 356 above the contract, which was 5,500.

In the forced draft trials the *Undaunted* developed 4,204 H.P. in the starboard engines, and 4,398 H.P. in the port engines, and made an average speed of 19.4 knots, beating her sister ship.

A New Atlantic Steamship.

(From the London *Engineering*.)

THE Fairfield Shipbuilding & Engineering Company, of Glasgow, has just handed over to her owners, the North German Lloyd's, another splendid steamer, named the *Lahn*, which is intended for their well-known Bremen and New York line. The *Lahn* is built of steel, and has great carrying capacity ; she measures 448 ft. by 49 ft. by 36 ft. 6 in. Her upper and main decks are constructed of teak, and all the deck-houses, etc., are of steel and teak. To protect the vessel from the heavy Atlantic seas, she has strongly-constructed turtle backs at both bow and stern. She has accommodation for 224 first-class, 106 second-class, and about 700 third-class passengers, and in addition there is ample accommodation provided for the ship's officers and crew, 170 in number. The first-class passengers will be accommodated on the main deck, the dining saloon being forward of the engines and boilers ; and on the same deck aft there is the second-class dining saloon, which is lighted by an open well from the ladies' saloon on the upper deck, with a large skylight above on the poop. All the furniture and the cabinet and uphol-

stery work of the saloons and cabins are of a very high character, and there is every convenience for the comfort of the passengers. Accommodation for the officers is provided in the central part of the upper deck; and there is a promenade deck of about 200 ft. in length for the exclusive use of the first-class passengers. The accommodation for the steerage passengers is on the lower deck.

The engineering department calls for very special mention, inasmuch as the engines are of a new type, and the *Lahn* is the first vessel into which they have been introduced. These engines are provided with five cylinders, working upon three cranks. Two of them are high-pressure cylinders, each having a diameter of 32½ in.; then there is one intermediate, 68 in. in diameter; and there are two low-pressure cylinders, each 85 in. in diameter. The length of stroke is 6 ft. The cylinders are arranged with the high-pressure above the low-pressure one (tandem fashion), with a piston-rod common to both. The glands on the top of each low-pressure cylinder, as also the glands on the bottom of its companion high-pressure cylinder, are enclosed in a steam-tight casing, and the two pistons act as guides for each other, thus obviating the necessity for a guide-rod proper in the high-pressure cylinder. Working on the middle crank, the intermediate cylinder is placed between the others. One of Messrs. Brown Brothers' combined steam and hydraulic reversing engines is fitted to the main engines. The crank, tunnel, and propeller shafts are all made of Messrs. Vickers, Son & Company's cast-steel. The water for condensing the steam is circulated through the tubes of the condenser by two centrifugal pumps, which can also be used for pumping water out of the ship if required. As is the practice at the Fairfield Works, the propeller blades are cast of manganese bronze. Steam is supplied to the engines by six double-ended boilers and one single-ended multitubular boiler, all constructed of steel and fitted with Fox's corrugated furnaces. They are designed for a working pressure of 150 lbs. per square inch.

On the measured mile at Skelmorlie the *Lahn* attained a speed of 19.46 knots per hour, or three-quarters of a knot in excess of the speed contracted, so that with the exception of the *Umbria* and *Etruria*, she is the fastest steamer yet built for the Atlantic service, thus putting the *Alaska* in the fourth place. The engines developed 9,500 H.P. On the day preceding that on which the official speed trials were made, the *Lahn* had a preliminary run of six hours, when she attained a mean speed of 18¾ knots per hour.

Within the past seven years the North German Lloyd's have had built at Fairfield no fewer than nine magnificent steamers, representing 44,142 tons register, and engines of a total of 65,200 H.P. indicated.

NAVAL PROGRESS OF THE UNITED STATES.

THE report of the Secretary of the Navy, as submitted to Congress, naturally dwells at some length on the construction of the new vessels which are to form the Navy. The Secretary considers it matter for congratulation that during the past year three manufactures necessary to the Navy have been established in this country: Armor-plate, forgings for heavy steel guns, and the Hotchkiss rapid-fire gun. He asks authority to build three more fast cruisers of types similar to those now under construction. We have already given accounts of the new vessels now under contract; we give below some extracts of interest from the report:

COAST AND HARBOR DEFENCE.

Congress at its last session appropriated $2,000,000 for coast and harbor defence vessels. This is the only appropriation heretofore made for a new Navy, the disposition of which has not as yet been determined by the Department. A board of officers was appointed on August 18 last to consider the subject, and they have reported, but the recent unavoidable absence of the head of the Department has prevented a proper review of the matter. Bids were opened November 1 last for the construction of one first-class torpedo boat, and two bids were found to have been received; one from the Herreshoff Company, of Rhode Island, and one from the Vulcan Iron Works, of Chicago. As both offer ample guarantees, and the plans submitted with the bids in each case are satisfactory, both offers may be accepted. If so, one will be paid for out of the appropriation for harbor defence boats. Beyond this the Department is not disposed to go in the construction of these unprotected torpedo boats. It is believed that at present the facts are against them. If one should sum up the results of the naval manœuvres of the last year or two, and admit the just consequences of the facts developed at the trials, it would be admitted that the range of usefulness of the unprotected torpedo boat is certainly very limited. When they can be seen they can be easily destroyed by machine and rapid-fire guns. This rules out all day fighting. No fleet has for years in its manœuvres wasted time experimenting with the use of torpedo boats in day fighting. The electric search light has, judged by the later trials, made their usefulness at night extremely doubtful. They are of value only upon occasions when they are invisible to an enemy. Such occasions are rare. The smoke of battle might conceal them, and for a nation having large classes of fighting ships they might prove of consequence, but that is not our situation at present. Now and then an unusual night, dark and foggy, would impair the efficiency of the electric search light, and an occasion favorable for these boats be presented. But the statement of the fact that they are of value only upon rare and accidental occasions should rule them out as a reliable weapon for coast and harbor defence. A nation cannot select the nights when it will defend its harbors. The occasion when it must are chosen by its adversary. The foregoing observations only shift the problem a little. The weapon carried by the torpedo boat is the most destructive known. Torpedoes—projectiles of all kinds containing high explosives—are incomparably the most powerful known. The abandonment of the unprotected boat does not involve the abandonment of the projectile. The facts concerning the unprotected torpedo boat have not as yet been generally formulated into the conclusions above stated, but a careful study of the facts has brought about a settled conviction upon the subject which will govern the action of this Department. In what way, then, shall the high-explosive projectiles be carried so as to certainly reach the object of attack in spite of machine and rapid-fire guns? One method possibly now taking practical shape is that of the submarine boat. Elsewhere in this report will be found a reference to the latest and probably the most promising trial of this class of boat thus far had. A number of claimants are pressing different devices for these boats. In order to ascertain whether any known and certain results have yet been reached in the progress of this branch of the art, the Department has, with the aid of the chief of the Bureau of Ordnance, prepared an advertisement inviting all persons who offer to guarantee the results of their work to submit proposals to the Department on March 1 next. It will serve to sift the claims, and may result in an effective and operative submarine torpedo boat. It is reasonably certain that boats entirely submerged except as to turret, small and protected against machine-gun fire, are practicable. The pneumatic dynamite gun is a weapon claiming consideration in this connection. Its range is such as to avoid the necessity of approaching closely to the object of attack, but the Department does not feel authorized to expend anything further upon this weapon until a trial shall have been had of the guns upon the boat now being built. If this trial should be favorable to the gun, it would remove many doubts and difficulties. This will be known within the next few months. If these various devices fail, protected boats can be built of small tonnage, of light draft, proof against machine-gun fire. To sum up this matter, the Department deems it unwise to follow at present the course of the European powers in building unprotected torpedo boats. It recognizes the power of the dynamite projectile, and believes it practicable to embody it in such manner as to insure that it will reach any desired object of attack in spite of known weapons, and upon that problem it is engaged.

I find myself unable to concur in the recommendation that the single-turreted monitors be repaired and made ready for coast defence vessels. An examination of their characteristics shows that outside of the ships in our own Navy, no antagonist could probably be found against which they could stand for a moment. They were good vessels for their time, but are entirely obsolete. The Admiral of our Navy, speaking upon this matter in 1876, said:

"Our monitors are protected by only about 4 in. of laminated plates, have a speed of less than 8 knots, with a tonnage of from 480 to 1,750 tons, and are armed with smooth-bore guns that will not penetrate the 4-in. solid iron plates at 900 yards (which the lightest iron-clads of foreign nations carry, backed by oak), while the lightest foreign iron-clads average about 4,000 tons displacement, a speed of 12 knots, and their guns will send projectiles through the thickest turrets our vessels carry, and they would run over and sink our squadron of small fry with hardly a scratch on their paint work."

This comparison was made in 1876. If made in 1887, it would be still stronger. A first-class modern iron-clad could safely anchor, surrounded by a fleet of these monitors, without any danger of injury to herself, and any one of her guns could send a projectile clean through the monitor from stem to stern. It would be little less than murder to send men in these at the present time to encounter any recently built iron-clad. I appreciate fully that it is only as a temporary expedient that it is suggested, and with the thought that in the absence of anything else these might be better than nothing. This has been the theory upon which over 50, and probably 75 millions have been spent since the close of the war. It is time to stop it, and be content only with the best. If every dollar is made to count upon something of real value waste will stop, and not before.

THE PNEUMATIC DYNAMITE GUN.

The pneumatic dynamite gun has been developed by private enterprise to the point where it merits immediate attention. The constant strife for mastery between the offensive and the defensive implements of war results periodically in new devices, changing entirely existing conditions. The improvements in armor and in the range and power of guns may be said to have kept pace each with the other. But as the weak point of an iron-clad is in its unprotected bottom, invention has been directed to torpedoes and torpedo boats, and these have been almost a mania with European powers during the last five years. Meanwhile the development of the machine-gun, and the introduction of steel nettings as a protection against the approach of the torpedo boat or the torpedo have limited so greatly the range of usefulness of the torpedo boat as to have caused a considerable distrust of its availability as a weapon. The principal difficulty is that its range of torpedo fire is so short that it is obliged to approach within a few hundred feet of the object of attack, which subjects it to destruction by machine-guns. The pneumatic dynamite gun attacks the problem by a new method. The company has demonstrated that by the use of pneumatic power projectiles containing large quantities of high explosives can be fired with safety and considerable accuracy a distance of between one and two miles. Whatever destruction a torpedo can do this projectile can do if accurately placed. Against its method of attack neither nets nor machine-guns are of any considerable use. It can be fired at such a distance as to be beyond the effective range of machine-guns, and the line of flight of its projectiles escapes nets. There are questions yet to be settled before its efficiency for naval purposes can be fully determined. This invention, like every other, has its own peculiar problems to solve, but the zeal and intelligence thus far given to the development promise ultimate success. It will at once be apprehended that in order to insure immersion of the projectile (necessary to the highest destructive power of the dynamite) the line of flight of the projectile must be in the arc of a circle—similar to mortar fire. To drop a projectile at any given point with such a line of flight has hitherto been deemed impracticable. The first impression of every expert has been to reject the gun for probable inaccuracy. The company has, however, claimed that by the use of pneumatic power an absolutely accurate and determinate force is employed, and this element of uncertainty removed. The demonstration has reached this point, that, given a fixed platform for the gun, as would be the case in coast defence, and opportunity for previous experiment to determine range, projectiles can be lodged at any desired point with great accuracy. The force can be gauged to a pound. For coast and harbor defence, to be fired from land batteries, its accuracy is substantially established, but for naval purposes other elements of difficulty intervene. The movement of the vessel destroys the possibility of availing of a range previously determined by experiment. An accurate range-finder is necessary. Those hitherto employed for determining the distance of objects have required a longer base line than can be had on board ship. Other difficulties also arise for consideration. However, the problems to be solved to make it thoroughly successful for naval purposes are receiving the most zealous and persistent study, and it is believed by those interested that in time all will be worked out. This gun, developed to its present point exclusively in this country and by private enterprise, promises to be the most notable event of the year. The claim made for it is quite revolutionary. It is claimed that by increasing the caliber of these guns an accurate range of from three to four miles can be had from a land battery, and that projectiles can be used containing not less than 400 lbs. of high explosives. The present demonstration, where the accurate range of one mile is shown, renders the claim not greatly improbable. The importance of this matter is somewhat due to the fact that the guns are not difficult of construction, nor, compared to other weapons, expensive, and could be made at any one of a dozen steel manufactories with their present plant; and unless there is something very greatly wrong in the assumed destructiveness of torpedoes and high-explosive projectiles the gun must be ranked as of extreme importance.

NAVAL RESERVES.

The policy of this country has always been opposed to the establishment of large permanent naval and military organizations. This policy for a country with a great coast line and important commercial interests almost necessitates the maintenance of auxiliaries in the way of naval and military reserves. The land forces have such auxiliaries in the shape of State militia or national guards. These constitute large bodies of troops, well organized and equipped, thoroughly well trained and disciplined, ready to take the field and to become a part of a regular military establishment when required. A public feeling seems to exist for the creation of a naval reserve. Committees of the Chambers of Commerce of New York and San Francisco have passed resolutions urging the organization of such a force, as a means for providing for the coast defence and meeting the increased demands of the regular naval establishment for men and vessels upon the outbreak of war. Inquiries have also been made at the Department from cities of the Great Lakes, and meetings have been held in cities of the South endorsing the formation of such a national organization. The Department has informed itself fully of the different systems of organization for coast defence and naval reserves at present in force in foreign countries, and is prepared to formulate a general plan for a similar organization to meet the requirements and conditions of our own institutions. It should resemble in organization that of the militia or national guard, rest upon the foundation of local interest, contemplate the employment and rapid mobilization of steamers enrolled on an auxiliary Navy list, and be calculated to produce the best results upon a comparatively small national expenditure. I ask for this question the earnest consideration of Congress. It may not be out of place as a branch of this subject to call attention to one of the incidental consequences of the policy pursued by other countries in this matter of a naval reserve. In time of war troop-ships or transports are in demand. Several European governments make an annual contribution, based on tonnage, to companies constructing new vessels. The consideration to the Government is a counter-agreement, permitting the Government to take such a vessel for a transport in time of war

upon terms named in the agreement. The Government officials are also consulted as to her mode of construction, and she goes on to the naval reserve list. These payments are incidentally in the nature of a subsidy to the ship-owner, and this, with the liberal payments for Government transportation of mails, etc., keeps a large fleet of merchantmen afloat as a reserve ready for a time of war. Without ships and trained seamen there can be no naval reserve. A notable illustration of the generosity and courage with which England pushes her shipping interest is seen in the manner in which she is at this moment dealing with the trade of the Northern Pacific. It has been thus far principally under the American flag and contributory to San Francisco and the United States. The British Government and Canada together are proposing for the establishment of a line of first-class steamers from Vancouver to Japan. The subsidy is likely to be $300,000 annually—£45,000 from England and £15,000 from Canada. There will also be contributed from the naval reserve fund probably $5 per ton annually for each ship constructed for the route, which will increase the sum by probably $125,000. Under such competition it is quite easy to conjecture what will become of the American flag and our resources in the way of a naval reserve in the North Pacific.

COAST DEFENSES OF THE UNITED STATES.

THE report of the Secretary of War as submitted to Congress contains some statements with regard to coast defenses, which we give below:

FORTIFICATIONS.

The same report comes from the Pacific as from the Atlantic Coast, that our harbors are destitute of fortifications, guns, and armament of every description. San Francisco is without a gun that can be fired with safety with present charges of powder and modern projectiles. General Howard has sent to this Department a report by a committee to the Legislature of California, giving a full description of the condition of the forts in the harbor of San Francisco, and urging immediate action for coast defense. . . .

During the past year no work has been done in connection with fortifications, as no appropriation for this purpose has been made since 1885. The existing works, many of which are of value for the defense of our harbors, are in a dilapidated condition, and extensive repairs are necessary for their preservation.

The importance of immediate action looking to the reconstruction of the defenses of our sea coast and lake frontier was fully set forth in my annual report of last year. Should the funds now asked for, $5,234,000, be appropriated by Congress, it is proposed to apply them to the construction of earthen gun and mortar batteries, which form by far the greater part of our projected defenses, and in which the question of armor is not involved; and also to the completion of our system of submarine mines, the details of which have been perfected. The works at present in contemplation are for the defense of the harbors at Portland, Boston, Narragansett Bay, New York, Philadelphia, Baltimore, Hampton Roads, Washington, New Orleans, and San Francisco. There appears to be no reason for further delay in beginning the important work of fortifying these great harbors.

Special attention is invited to the needs of the Engineer School of Application at Willett's Point. The importance of the Battalion of Engineer Troops as a Torpedo Corps, practised in the rapid and certain planting of submarine mines, cannot be too strongly enforced. In order that this school may continue to perform its work with efficiency, the appropriations requested in the estimates already submitted to Congress should be made.

ORDNANCE DEPARTMENT.

During the fiscal year ending June 30, 1887, 41,106 rifles and carbines were manufactured at the National Armory.

The question of a reduced caliber for small arms is now under careful consideration and experiment by the Department; and while the present caliber, .45, meets the demands of the service in a satisfactory manner, and was adopted fifteen years ago after extended tests, the interest awakened in the military world justifies a further examination and report upon this subject. A magazine gun has become a necessity, and during many years the Department has endeavored to find one that would give satisfaction to the Army. From what we learn of the magazine systems abroad, nothing is to be gained by haste, and the Springfield rifle must continue to serve our purpose until a magazine gun that will do credit to the inventive genius of our people is adopted. It is to be observed that under the existing law, Revised Statutes, section 1,672, only the Springfield guns can be manufactured by this Department. We are unable, therefore, to make magazine guns, and can only test and examine the magazine guns and systems brought to the Department by dealers or inventors. It is very desirable that this statute should be so far modified that we can purchase or manufacture magazine guns for experiment and trial. Large appropriations for ammunition and target material are asked for. A matter so necessary to the effectiveness of our small army deserves the favorable consideration of Congress.

In view of the success attained by our steel-makers, it is apparent that the assurance that the outlay for the necessary plant will prove remunerative is all that is required to produce in this country the largest gun forgings of suitable quality. It is believed to be of vital importance that appropriations be annually made by Congress until our present need of modern guns is supplied and the aid that our steel industry demands is assured. As a step in this direction an appropriation of $1,500,000 for the forgings of 8-in. and 10-in. B. L. steel guns has been recommended in the estimates. This sum would procure the steel for about fifty 8-in. and forty 10-in. guns, and should be made available until expended. A trial of the improved Powlett carriage should be authorized. It was first tried by this Department, and its favorable action induced further trial by the Navy Department. The conditions differ so much in the two Departments that appropriations for renewed trials by this Department are recommended.

The recommendation of General Schofield, that each artillery post be furnished with the means for instruction in modern ordnance, is a very important one, but the Department is unable to comply with the request, as we have no guns suitable for such target practice and technical instruction. In no branch of the Service is technical instruction and daily experiments and practice in the use of its weapons more demanded than in the artillery. Infantry can be rapidly organized and soon made serviceable; but the trained and well-instructed artillery soldier, whether officer or enlisted man, is only obtained by long and patient work. It is earnestly hoped that, if guns cannot be had for fortifications, appropriations can be made for the purchase or manufacture of enough guns to employ the artillery and fit them for any emergency. The light batteries in this division are said to be in good condition. It is probable that new 3.2-in. steel B. L. rifled guns, with proper carriages, will be put in their hands during the coming season. A concentration of these batteries may be made at Fort Niagara, N. Y., which affords better facilities for their work than any other place in the division, when that post can be prepared for their reception.

The Rifles of Modern Armies.

(From the London *United Service Gazette*.)

THE decision to adopt a magazine rifle has not been arrived at any too soon. Germany, France, Italy, Austria, Switzerland and several other continental nations have already adopted it; and although the Martini-Henry is a fairly good weapon, considered as a single loader, we shall, so long as we possess nothing better, be far behind the vast majority of the military powers.

It may here be pertinent to give a list of the rifles which are now in actual use in various countries. These are as follows:

Afghanistan, Martini-Henry; Argentine Republic, Remington; Austria, Werndl, Mannlicher (M. 85); Belgium, Albini-Braendlin; Brazil, Comblain; Chili, Kropatschek; China, Remington, Snider, Hotchkiss, etc.; Colombia,

COMPARATIVE TABLE OF MODERN RIFLES.

System.	Weight of Rifle.		Caliber.	Weight of Powder.	Weight of Bullet.	Weight of Cartridge.	Rifling. No. of Grooves.	Rifling. Twist in Calibers.	Velocity in feet per second.		
	lbs.	oz.	Inch.	Grs.	Grs.	Grs.			Muzzle.	1,000 yds.	2,000 yds.
Werndl	9	13½	.433	77	370	610	4	1 in 50	1,439	620	328
Martini-Henry	8	12	.45	85	480	766½	7	1 in 49	1,253	662	388
Gras (M. 74-80)	9	4	.433	81	386	676	4	1 in 50	1,430	642	346
Mauser (M. 71-84)	10	2	.433	77	386	663	4	1 in 50	1,410	628	335
Vetterli	10	8	.414	55	312	465	4	1 in 63½	1,427	593	302
Kropatschek	9	14½	.433	81	386	676	4	1 in 50	1,430	621	315
Jarmann	10	1½	.397	77	337	620	4	1 in 55	1,536	675	377
Berdan	9	4	.42	77	370	610	6	1 in 50	1,444	645	353
Springfield	9	5¼	.45	70	500	706	3	1 in 49	1,350	675	404
Remington (M. 71)	9	0	.433	77	386	638	6	1 in 59	1,340	630	325
Enfield-Martini	9	6	.402	85	384	680	7	1 in 37½	1,570	719	424
Mannlicher (M. 85)	9	8½	.433	77	371	656	4	1 in 68½	1,437	622	315

Remington; Denmark, Remington; Egypt, Remington; France, Gras, Lobell, Kropatschek; Germany, Mauser, Mauser (M. 71–84); Great Britain, Martini-Henry, Snider; Greece, Gras (M. 74); Holland, Beaumont-Chassepot (modified); Italy, Vetterli, Vitali-Vetterli; Freddi (?); Japan, Murata; Madagascar, Remington, Snider; Mexico, Lee; Montenegro, Kenka, Dreyse; Norway and Sweden, Jarmann; Persia, Chassepot; Peru, Beaumont (modified); Portugal, Guedes (Kropatschek); Russia, Berdan (M. 71); Servia, Peabody-Grun; Spain, Remington (M. 71); Switzerland, Vetterli; Turkey, Martini-Henry, Peabody-Martini; United States, Springfield, Lee; Uruguay, Remington.

Some of the more important of these modern breech-loaders (leaving aside for the present the magazine question) are compared in the accompanying table.

Upon the whole, if we regard these weapons merely as single-shot rifles, the Enfield-Martini, the Springfield, and the Jarmann may be taken to be the best of the 12. The real superiority, however, of the Enfield-Martini becomes more apparent than ever when we compare the heights of the trajectories of the three selected rifles at various ranges. These are as follows:

HEIGHT OF TRAJECTORIES IN FEET.

	500 Yards.	1,000 Yards.	2,000 Yards.
Springfield	8.5	46.8	343.0
Jarmann	7.2	42.9	348.0
Enfield-Martini	6.7	39.0	298.4

But even the Enfield-Martini, good as it is, is a very inferior weapon as compared with three foreign rifles of recent invention. These are the Lobell, which has been adopted by the French Government, and which appears to be a combination of the Kropatschek and Hebler systems, the Pieri, and the Hebler. The Enfield-Martini is also slightly inferior to the Freddi, a recoil rifle, which the Italian government proposes to adopt. Of these powerful new weapons we are only able to give the meagre details that follow, for great secrecy is observed with regard to the performances of each of them. For purposes of comparison we put the Enfield-Martini by the side of them:

	Caliber.	Rifle.	Weight of Powder.	Bullet.	Twist in Calibres.	Muzzle Velocity.
	inch.	oz.	grs.	grs.		ft. p. sec.
Enfield-Martini	.402	150	85	384	1 in 37½	1,570
Freddi	.315	116	83	225	?	1,640
Hebler	.296	158½	83	225	1 in 15½	1,968
Lobell	.307	?	?	?	?	2,034
Pieri	.323	?	83	?	?	2,057

This table certainly makes it appear that reduction of caliber and of weight of bullet, without proportionate reduction of weight of powder charge, and with an increased twist in the rifling, gives a highly increased velocity; and it was probably with these statistics before them that the Government the other day decided that the Enfield-Martini was not good enough for the British army, and that the service required not merely a magazine rifle, but a magazine rifle with a caliber of about .31. The British bullet of the future will be, therefore, no thicker than an ordinary lead-pencil. So much for modern military rifles regarded simply as single-loading weapons.

Many of the rifles of which we have already spoken are magazine or quick-firing rifles. The exact type of this class of weapons which is to be adopted in Great Britain does not appear to have yet been determined, but it is understood to be either the Improved Lee or the Lee-Burton. Both of these have detachable magazines, and the breech-bolt mechanism is the same in each. All the modern magazine rifles are, in fact, constructed on the breech-bolt system, though the details vary somewhat in almost every case. It is in the form and position of the magazines that the greatest divergencies prevail. As Captain W. H. James has classed them, magazines may be divided into—(1) those in the butt, (2) those under the barrel, (3) those over the barrel, and (4) those under the breech. "No nation," he says, "has adopted the first and third forms. Germany, France, Switzerland, Sweden, and Portugal have the second, with magazines under the barrel, in the systems of Mauser, Kropatschek, Vetterli, Jarmann, and Kropatschek-Guedes respectively." These guns are all difficult to load, and the balance of the piece is altered each time the gun is fired. The chief objection to the first class lies in the difficulty to load. The third class is objectionable because the aim is obstructed by the magazine over the barrel. The best position is that of the fourth class, with the magazine under the breech, as in the Mannlicher, Schulhoff, Pieri, Lee, and Improved Lee.

The Lobell, the new French rifle, has its magazine under the barrel; but, save that the receptacle contains eight cartridges, and that smokeless powder is used, little is known about it.

Of the new German rifle, Mauser (M. 71–84), there is more to be said. It is sighted up to 1,600 meters (1,750 yards), and the barrel is of mild cast steel, slightly diminishing in thickness at the muzzle. The rear end of the bore is considerably enlarged to serve as a cartridge chamber, and it is closed by the breech bolt. The rifle is 4 ft. 3 in. long, and, with the bayonet, 5 ft. 11 in. When empty it weighs 10 lbs. 2 oz., and when loaded 11 lbs. The bayonet weighs 1 lb. 10 oz. The magazine, which will contain eight cartridges, is a tube of thin sheet steel, inside of which, and fastened to the forward closed end, is a spiral spring. This spring forces down the cartridges to a point below the breech, where, when the bolt is withdrawn, the lowest one is seized in a spoon and carried upward until the point of the bullet is in position to enter the cartridge chamber. Meantime the magazine is closed by a lip which is affixed to the lower side of the mouth of the spoon. The pushing forward of the breech bolt drives the cartridge home and simultaneously depresses the spoon, while it also sets free a check which prevents another cartridge entering the spoon until the bolt is once more withdrawn. This withdrawal pulls out the empty cartridge by means of an extractor which forms part of the end of the bolt. The check above spoken of may also be set in action independently, and the rifle can then be used as a single loader. Blank cartridges made with a hollow wooden bullet painted red are served out for sham fights and practice. The service cartridge is 3.07 in. long. Experiments have recently been made with an improved cartridge containing 89½ grains of powder and a steel-covered bullet.

The new Austrian rifle, Mannlicher (M. 85), carries its

magazine, a detachable one, under the breech, and the manipulation of the breech bolt simply involves a straight backward and forward motion, so that the gun can be fired and loaded without removing it from the shoulder. Each magazine holds five cartridges, and, when destined for use, is placed in a hollow frame beneath the breech. This frame has bent rocking levers which project into the magazine, entering from the rear and below. The levers act as carriers for the cartridges, and feed them up to a point at which they can be acted upon by the forward motion of the bolt, and so thrust into the barrel. The ammunition is kept packed in magazines, each of which is a tin case, costing about 1d., and weighing 385 grains. The disadvantage of the rifle is that it cannot be used as a single loader.

The Improved Lee is free from this grave drawback. Like the Mannlicher, it has a detachable magazine which holds five cartridges; but it can be used as a single loader, whether the magazine be attached or not. A full magazine can be substituted for an empty one in two seconds. Like the Mannlicher, the Lee can be fired again and again without removing it from the shoulder. It is now almost certain that some modification of this weapon will be adopted for the use of the British army.

Various guns which utilize the recoil of each discharge for the purpose of ejecting the empty cartridge, and even substituting a full one, and in some cases firing it, might also be noticed. Captain Freddi has invented one, which the Italian Government has proposed to adopt, and which seems to be an excellent weapon. The Freddi system only, however, makes a restricted use of the recoil, which is employed merely to eject the empty cartridge, open the chamber, and cock the rifle. It is difficult to explain the mechanism without the aid of diagrams; but in practice the Freddi is worked as follows: From a cartridge box, which hangs at the side of the rifle, the soldier takes a cartridge and inserts it in the receiver as in an ordinary single loader. He then brings the gun to the shoulder, fires it by pressing the trigger with his forefinger, introduces a new cartridge, and with his thumb presses a button, which closes the breech. He can fire 24 rounds in a minute, and he can always use the gun as a single loader by working the bolt himself instead of letting the recoil work it for him. The weight of the gun is only 7 lbs. 4 oz., the complete cartridge weighs but 398 grains, and, as we have already seen, a muzzle velocity of 1,640 ft. per second is attained. When we consider that the new Mauser weighs 10 lbs. 2 oz., that its cartridge weighs 663 grains, and that its muzzle velocity is only 1,410 ft. per second, some of the advantages of the Freddi become immediately apparent. The weight of the Mauser (M. 71-84) and 100 cartridges is about 19 lbs. 9 oz.; that of a Freddi and 100 cartridges is only about 12 lbs. 14 oz. Indeed, a man armed with a Freddi and carrying 200 cartridges would be less heavily weighted than a man armed with a Mauser and carrying only 100 cartridges. From the point of view of the marching soldier, if from no other, this consideration is a very important one. The relative lightness of the Freddi cartridge is due solely to the caliber of the rifle, being .315, as compared with the Mauser's .433. The relative lightness of the rifle is due to the fact that the gun, and not the soldier, has to take the force of the recoil. In ordinary rifles it is necessary to make the weapon heavy in order that the soldier may be assisted in supporting the shock; but that necessity not existing in the Freddi, the gun can be made as light as possible.

Railroads in Japan.

[Report of T. R. Jernigan, U. S. Consul at Osaka, Japan, to the State Department.]

The Government of Japan has recently issued a series of regulations on the subject of private railway enterprises. Before considering the more important provisions of these regulations, a brief synopsis of the history of railroads in Japan may be interesting.

Commodore Perry was the first to give the Japanese a practical illustration of the idea of a railroad, but it was not until 1870 that the first railroad was introduced into Japan with a view to profit and for commercial purposes.

It was during the year 1870 that the first rail was laid of the road now connecting Tokio and Yokohama. This road was opened in 1872; it is 18 miles long, and cost nearly $160,000 per mile.

The second line was constructed in 1876, and runs between Hiogo and Kioto, *via* Osaka. It was, and is now, the purpose of the Government to connect by rail the new and old capitals, Tokio and Kioto, but this larger project yielded to the pressing demands of trade, which, originating at Osaka, the great commercial center, pointed out the necessity of a line to the open port of Hiogo.

The civil war of 1876 (called the Satsuma rebellion) interrupted all railroad enterprises, and it was not until 1880 that the line under consideration was completed from Kioto to Otsu, on the south-eastern corner of Lake Biwa. This line from Hiogo to Otsu is 58 miles long; its cost has been nearly $140,000 per mile.

Since 1880 there has been considerable activity in building and projecting railroads in Japan. In addition to the two roads named above, there are opened for traffic the following: Tsuruga-Ogaki, 49 miles; Tokio-Mayebashi, 68 miles; Shinagawa-Akebani, 13 miles; Omiya-Utsonomiya, 5 miles; Takasaki-Yokogawa, 18 miles; Handa-Nagoya (including extension to Kiyosu), 30 miles; Naoetsu-Sekiyama, 18 miles. This makes 277 miles now open.

The following lines are now under construction or in contemplation: Ogaki to Kiyosu, 10 miles; Yokogawa to Sekiyama, 80 miles; Yokogawa to Nagoya, 120 miles; Nagahama to Ishibashi, 40 miles; Utsunomiya to Sendai, 150 miles; Sendai to the port of Shiogawa, 10 miles; a total of about 410 miles.

The lines for all these roads have been surveyed and the roads built by foreign engineers; but on examining the list I find that American engineers and mechanics have been virtually ignored.

Even now, when public opinion in Japan is almost wholly occupied by the subject of railroads, and no less than 34 new railroad projects have been started within the last six months, 21 of which involve an aggregate capital of $48,765,000, I am unable to perceive any change in this direction favorable to the United States.

The imperial ordinance entitled "Private Railroad Regulations" contains 41 articles, and might be termed by lawyers a misnomer. An examination of some of its articles will show that such a name would not be misapplied, for while the title of the ordinance implies that railroad enterprises might be undertaken by private individuals, it is clear that no such enterprises could flourish a day that did not have the full sanction of the Government.

The application for the construction of a road has to be made by no less than five persons, who shall jointly through the municipal Government in the jurisdiction of which it is intended that the head office of such railroad shall be situated, transmit to the central Government, in the form of a petition for leave to establish the proposed railroad company, such information as is necessary to explain the undertaking.

After the petition has been submitted, should it appear that the proposed undertaking will interfere with any existing railroad, or that the local condition, etc., do not show any necessity for the construction of the new line, then the petition will not be granted; otherwise a charter authorizing the work of constructing the line and incorporating the company will be issued, after having received the approval of his Imperial Majesty.

If the charter should not be obtained, it will not be competent for the promoters to raise any of the capital by means of shares, or, in the name of the company, to commence the work of constructing the railroad.

The work on the railroad must be begun within three months from the date of the charter, and finished within the time fixed by said charter. If an extension of time be desired, it must be made through the municipal Government within two months, but such extension cannot amount to more than half the period originally fixed. The gauge, unless specially sanctioned to the contrary, shall be 3 ft. 6 in.

No company can alter its rules or methods of working without the sanction of the Government, and rules and

rates of freight or charges for passengers must be fixed under, and all alteration or changes submitted to, the approval of the Chief of the Railroad Bureau, and so must all changes in the hours of starting and arriving, and the number of trains run, etc.

When a charter for a railroad is granted only for a special period, the Government shall have the right at the expiration of such period to buy up the line and its accessories, and the price at which such purchase shall be made shall be a price to be calculated from the average price of the shares during five years previous to the date of purchase.

Before any charter can be granted detailed plans and estimates must be submitted to the Railroad Bureau and approved by the experts of that office. Other exceptional powers of inspection are reserved to the Railroad Bureau, such as discretionary inspection during construction, compulsory inspection and approval on completion of the work and before traffic is commenced, and discretionary inspection while the railroad is in use. The tendency of such a system of espionage is to discourage the formation of private companies, which is greatly increased when it is proposed to subject honest enterprise to the inconvenience of commencing the work of construction within three months from the date of the charter, with a possible extension of not more than a month and a half. The above compilations show that the purpose of the Government is to retain in theory, as well as practice, control of all the railroads in Japan.

Another subject of importance to American workshops is now claiming the attention of the press in Japan.

The *Jiji Shimpo*, an able and independent native journal, recently referred to the superior construction of American rolling stock and American workshops. Enlarging upon the subject in its relation to English workshops, the *Japan Mail*, an English journal, asserts that experience in Australia has proved the superiority of English locomotives over American.

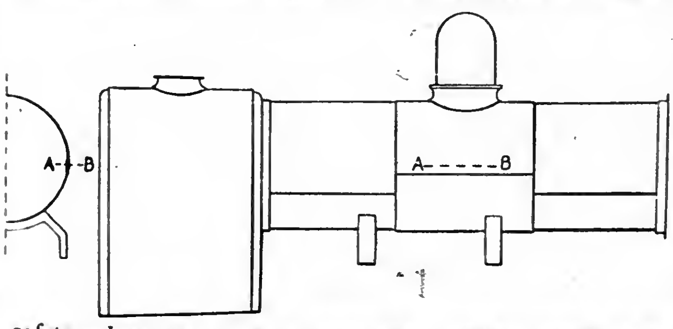
LOCOMOTIVE BOILER EXPLOSIONS ON BRITISH RAILROADS.

(*Continued from page* 566, *Vol. LXI.*)

We continue below the condensed summary of the reports made to the British Board of Trade by its Inspectors on the explosions of locomotive boilers on the railroads of that country.

INSPECTORS' REPORTS.

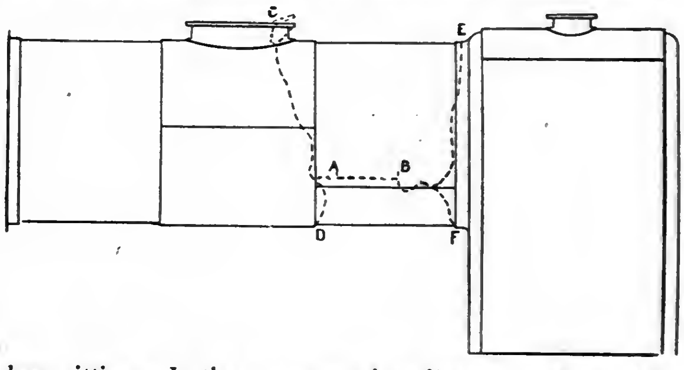
May 5, 1862, the locomotive of a freight train on the London & Northwestern exploded its boiler while shifting cars at Harrow. The explosion took place on a siding, just after the engineer had opened the throttle to start. The engine was a heavy one with 18×24 in. cylinders and six 60-in. wheels, all coupled. The boiler was 52 in. diameter of barrel and 14 ft. 2 in. long; it had 237 tubes, $2\frac{1}{8}$ in. diameter. The engine was nine years old; it had been damaged in a collision three years before, and when repaired the boiler had received a new set of tubes. The usual working pressure was 120 lbs., and there were three



safety-valves, set to that pressure. The explosion killed the fireman and injured the engineman badly. The barrel of the boiler opened just above the seam in the middle ring, and the upper plates were torn off and thrown over to the right, most of the tubes being torn out and thrown in the opposite direction. Examination showed that the plates were badly corroded in two or three places along the seams. The weakest spot was on the line *A B* in the accompanying diagram, where the plate had been reduced from its original thickness of $\frac{3}{8}$ in. to a little over $\frac{1}{16}$ in. It was at this point that the barrel gave way, and the weakness caused by the corrosion was the cause.

November 8, 1862, a locomotive on the Great Western exploded its boiler while standing in the shed at Paddington station. Fire had been started about two hours before. The explosion killed three cleaners who were at work in the shed. The fire-box remained intact, but the barrel was torn away from it and was broken into several pieces, some of which went through the roof, one landing 300 ft. away. The engine was lifted from the track and turned completely around. This was a heavy passenger engine with 18×24 in. cylinders, one pair of 8-ft. drivers, and six 42-in. bearing wheels. The barrel of the boiler was 57 in. diameter and 10 ft. 9 in. long. It was of $\frac{3}{8}$-in. iron plates and had 303 brass tubes, 2 in. diameter. There was no evidence to show that water was low or the safety-valves defective, and steam had not reached 120 lbs., the point at which the valves were set. There was, however, extensive corrosion and pitting, chiefly along the seams on the lower part of the barrel. The Inspector makes this and the previous explosion occasions for urging more frequent tests of boilers and more care in inspection and in watching for evidences of corrosion.

May 30, 1864, the boiler of the locomotive of a passenger train on the London & Northwestern road exploded just as the train had stopped at Overton station. The engineman and fireman were slightly hurt. One ring was torn completely off the barrel, and the force of the explosion moved a shed standing by the track. Just before the explosion the gauges showed plenty of water in the boiler and about 100 lbs. steam pressure. No leak had been noticed about the boiler. The engine had 16×21-in. cylinders and one pair of drivers 69 in. diameter. The boiler was of $\frac{3}{8}$-in. iron, 47 in. diameter of barrel, and 10 ft. long. This was another case of corrosion, the plates showing



deep pitting. In the accompanying diagram the line *A B* shows the point of greatest corrosion and consequent weakness. The irregular lines *C D* and *E F* show the lines of fracture, and the space between them marks the part of the plate torn off by the explosion. The Inspector in this case again urges the necessity of frequent inspection, and the danger of allowing boilers to go without examination as long as this one had been left. He refers also to the corrosion resulting from the chemical and galvanic action of the iron and copper used in boiler construction. As to construction, he makes the following recommendations:

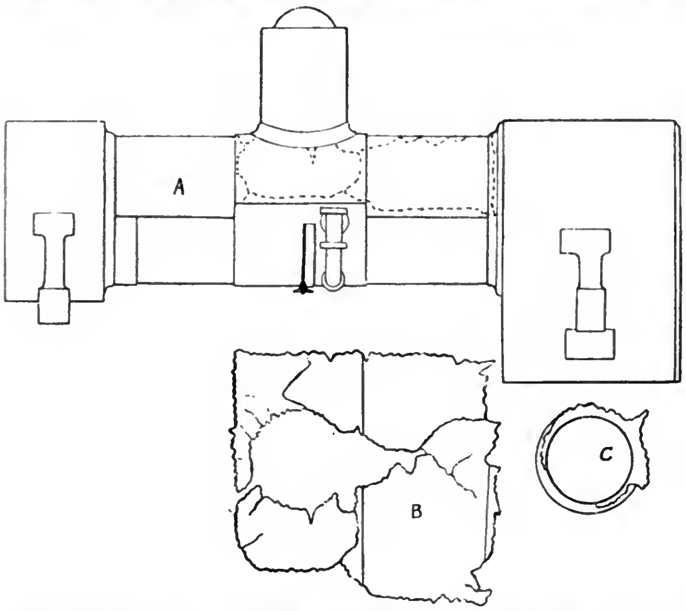
"1. The barrels should be made more perfectly cylindrical by the use of butt-joints and cover-strips, in place of the lap-joints commonly used.

"2. The longitudinal joints should be placed in all cases above the water-line instead of below it, so as to prevent the risk of corrosion from the different actions (chemical and galvanic) before referred to; there is no necessity for more than one longitudinal joint in each ring.

"3. The boiler should be firmly attached to the framing at one end only, the other end being allowed to slide backward and forward to allow for changes of temperature, as is now frequently, but by no means always, done.

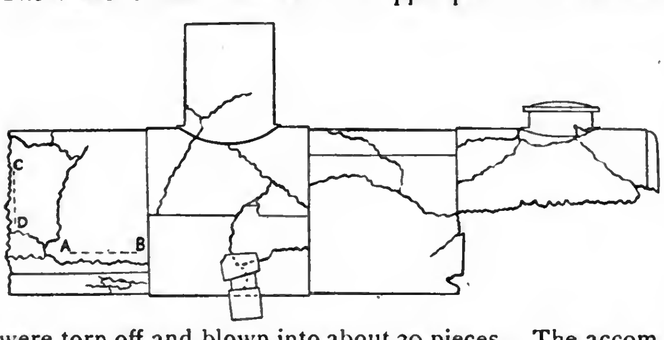
"4. The barrel should be strengthened at the vertical (or transverse) joints and at intermediate intervals, either by the addition of belts or by the use of plates rolled thicker in the middle as well as at their edges. A locomotive boiler thus reinforced in a proper manner would leak when the plates had been eaten through by corrosion between the strengthening belts, but could never explode."

May 9, 1864, a boiler exploded on the locomotive of a passenger train on the Metropolitan line of the Great Northern road, just as the train was stopping at Bishop's Road station. The engineman, fireman, a brakeman, and a passenger were badly hurt. The roof of the station over the engine was blown off. The engine in this case had 16×22-in. cylinders and six 60-in. wheels, all coupled. The boiler barrel was of $\frac{3}{8}$-in. iron, and was 45 in. diameter and 10 ft. long. The working pressure was 120 lbs., and there was no reason to believe that it had been exceeded. The boiler in this case was 14 years old, and had had three sets of tubes, the last having been in use 14 months. Slight repairs had been made, and two patches put on at the same time the last set of tubes were put in. The accompanying diagram shows the boiler, *A* being a general view of it, the dotted lines showing the lines of fracture. *B* is a sketch of the plates torn off the top of



the barrel, and *C* is the bottom of the dome as torn out from the plate *B*. The Inspector believes this to have been another case of weakening from corrosion, and repeats the recommendations made in the preceding case.

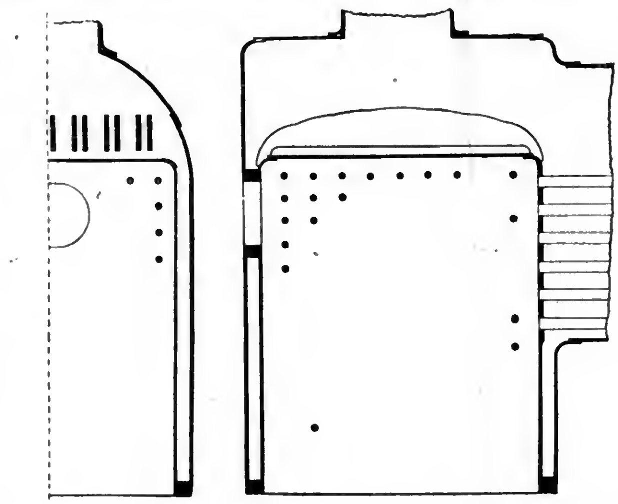
May 15, 1864, the boiler of a locomotive on the Midland road exploded just after the train had stopped at Colne station with a goods train. The engine had 16×24-in. cylinders and six 60-in. wheels, all coupled. The boiler was 51 in. diameter of barrel and 11 ft. 6 in. long, made of $\frac{7}{16}$-in. iron. It was 10 years old, and was using its third set of tubes. The usual working pressure was 140 lbs. The barrel of the boiler and the upper part of the fire-box



were torn off and blown into about 20 pieces. The accompanying diagram shows the fractured portion, the irregular lines showing the lines of fracture. The smoke-box and fire-box remained attached to the framing. This was another case where there had been extensive corrosion, the weakest point being along the longitudinal line of rivets.

It will be noticed that three serious explosions have occurred on different roads within a few days, all from the same cause. The Inspector makes the same recommendations in each case.

September 16, 1864, the boiler of a locomotive exploded at Camden Road station on the North London road, just as the train was starting from the station. The engineman was badly hurt and the fireman killed. The engine was a tank engine with 15×22-in. cylinders, four coupled wheels 63 in. diameter, and leading wheels 42 in. diameter. The boiler was 10 years old, outside shell of iron, and copper fire-box. The explosion occurred in the fire-box, and commenced at the angle formed by upper and rear sides of the left-hand copper plate. This plate was torn off irregularly, blown inward, and partially bent over against the tube-sheets. The sudden and violent escape of steam lifted the engine up and turned it over on the left side. The copper plates were stayed to the outside shell by copper stays $\frac{3}{4}$ in. diameter spaced $4\frac{1}{2}$ in. apart in each direction. In the side-sheet there were 108 of these stays, of which 89 remained attached to the iron shell, their screwed ends being torn out of the copper sheet. The other 19 remained attached to the copper plate, and all of these showed signs of old flaws or breaks. Five of the stay-bolts in the back sheet also gave way. The accompanying diagrams show a longitudinal section and a half

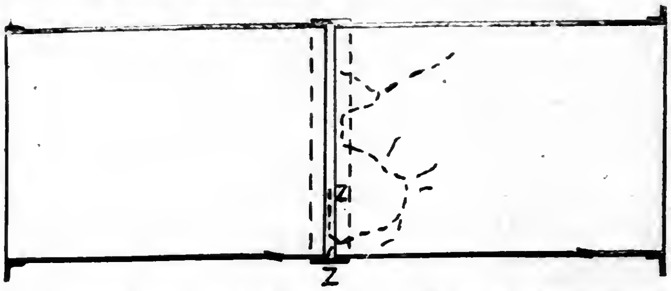


cross section of the fire-box, the position of the broken stay-bolts being shown by the black dots. The Inspector finds in this case that the rivet-heads on the stay-bolts had been generally burned away on the inner side of the fire-box. He believes that the explosion was due partly to the giving way of the stay-bolts and partly to the absence of hanging stays to connect the crown-bars to the outer shell of the boiler.

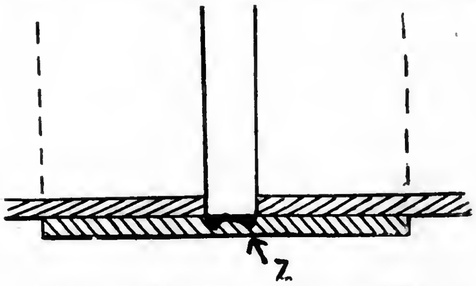
January 14, 1865, the boiler of a Great Northern locomotive exploded in the shops at Peterboro. The engine was off its wheels at the time, and the boiler had just been overhauled and several patches put on the fire-box. It was filled with water and steam raised in order to test it; just as the pressure reached 125 lbs. it exploded, the two forward rings of the barrel being torn off, leaving the rear end almost intact. The roof of the building was blown off and several other engines in the shop damaged. In this case the boiler was 48 in. diameter of barrel and 10 ft. long. The shell was of $\frac{7}{16}$-in. plates, the rivets $\frac{3}{4}$ in. diameter, spaced $1\frac{3}{4}$ in. apart. Two extensive cracks or furrows were found in the fractured plates, and they undoubtedly began to give way at those weak points. As in several cases heretofore referred to, these furrows had apparently been started by the calking tools, and had been enlarged by corrosive action.

February 12, 1865, the boiler of a locomotive on the Great Western road exploded at Leominster while the engine was waiting to start with a goods train. The engine had 15×24-in. cylinders, four coupled 60-in. drivers, and 42-in. leading wheels. The boiler was 44 in. diameter of barrel

and 10 ft. long. The engine was built in 1849; in 1860 the fire-box was altered to burn coal, and at that time a belt 7 in. wide and $\frac{7}{16}$ in. thick was added round the middle of the barrel; but at the time a space of $1\frac{1}{4}$ in. was left between the edges of the plates. The accompanying sketches show the barrel of the boiler, with the lines



of fracture, and (on a larger scale) the peculiar method in which the extra plate was put on. This space left between the plates was a direct invitation for corrosion to begin,



and its working is shown in the sketch. There is no doubt that the boiler gave way first on the line *Z Z* on the sketch.

January 1, 1866, the boiler of the engine of a coal train on the Blyth & Tyne road exploded at Gosforth, where the train was waiting on a siding. The engine was a passenger engine, temporarily employed on coal work; it had 16×24-in. cylinders, four coupled 66-in. drivers, and 54-in. leading wheels. The boiler was of $\frac{1}{2}$-in. iron, $45\frac{1}{2}$ in. diameter of barrel and 10 ft. long. The fire-box was of $\frac{7}{16}$-in. copper, and was 45 in. long, 64 in. high, and 40 in. wide at bottom, increasing to 44 in. at top. The engine was four years old, and had had general repairs nine months before the explosion, when a new set of tubes was put in. In this case the fire-box gave way on the left side, the side-sheet being torn off and blown out; the force of the explosion lifted the engine and turned it over on one side. About one-fifth of the crown-sheet was carried away with the side-sheet. The Inspector found that the copper sheet was badly worn, and that the heads of many of the stay-bolts had been burned off, and held that these defects caused the explosion. He also considered that there had been neglect in not inspecting the boiler more carefully, as such inspection might have revealed the weakness of both sheet and stays.

January 31, 1868, the boiler of a passenger locomotive on the Lancashire & Yorkshire road exploded just after the train had stopped at Halshaw Moor. The engine had 15×20-in. cylinders, one pair of 70-in. drivers, and 42-in. leading and trailing wheels. The fire-box was of copper, the sides and top being in one $\frac{1}{2}$-in. plate 12 ft. 9 in. long in all; the back sheet was also $\frac{1}{2}$ in., with a thickening piece $\frac{5}{8}$ in. thick around the fire-box door; the tube-sheet was $\frac{7}{8}$ in. thick. The stay-bolts between the fire-box and outer shell were 1 in. diameter and spaced 5 in. apart. The engine was 20 years old; it had been several times repaired, the last time about a year before the accident. At that time a patch was put on the back sheet of the fire-box. The fire-box gave way, the side-sheet and part of the crown-sheet being doubled up together, the stay-bolts in the side-sheet being either drawn through the copper sheet or broken off. Investigation showed that many of the stay-bolts had their heads burned off, and that the copper sheets had been worn down in places to $\frac{1}{4}$ in., $\frac{3}{16}$ in., and in one place (where the fracture probably started) to $\frac{1}{8}$ in. in thickness. This weakness caused the explosion, which might have been prevented by proper inspection of the boiler.

October 25, 1870, the boiler of a passenger engine on the Manchester, Sheffield & Lincolnshire road exploded just as the train was starting from Deepcar station. A piece of the outer crown-sheet about 2×4 ft. was torn out and thrown up on a bank 35 ft. away, and the side-sheets were also torn out, one of them being found 500 ft. off. Inspection of the plates showed a deep flaw in one of them, where it began to give way, which had been in the plate apparently when it was first put in the boiler. A sufficient safety test would probably have exposed this flaw.

January 29, 1871, the boiler of the engine of a passenger train on the Northeastern road exploded while the engine was standing at Northallerton. The engine was 24 years old, and had been last repaired a few months before, when a new steam-pipe was put in. The whole of the barrel of the boiler was torn away from the smoke-box and fire-box, and the engine was almost destroyed. The barrel plates were picked up in 9 pieces. The boiler was of elliptical form, 44 by 41 in., the barrel being formed of six $\frac{3}{8}$-in. plates running its full length, with joints overlapping about 2 in. An old flaw was found in the angle-iron connecting the barrel with the fire-box, but the fracture apparently did not start there. The Inspector thinks it "difficult to assign the exact cause of the failure of this boiler at the time it occurred; but it is fair to assume that it was in some unexplained way connected with the repairs which it had just undergone. Considering its age and faulty form, it was a great mistake to have sent it out to work after repair without having applied to it a pressure test, particularly as it was three years since the last test had been applied. It is also to be noted that a margin of 30 lbs. between the test and working pressure is not sufficient for safety."

For 1871 the railroad companies were required for the first time to make reports of all the accidents occurring. In that year two cases of accidents to boilers were reported. One is noted above; the other was not considered worth a special inquiry, as it was only a case of the collapse of a tube, an engineman having been slightly scalded in the face by the escaping steam. Very few of the boiler explosions, however, escaped investigation, nearly all of them being referred to the Inspectors.

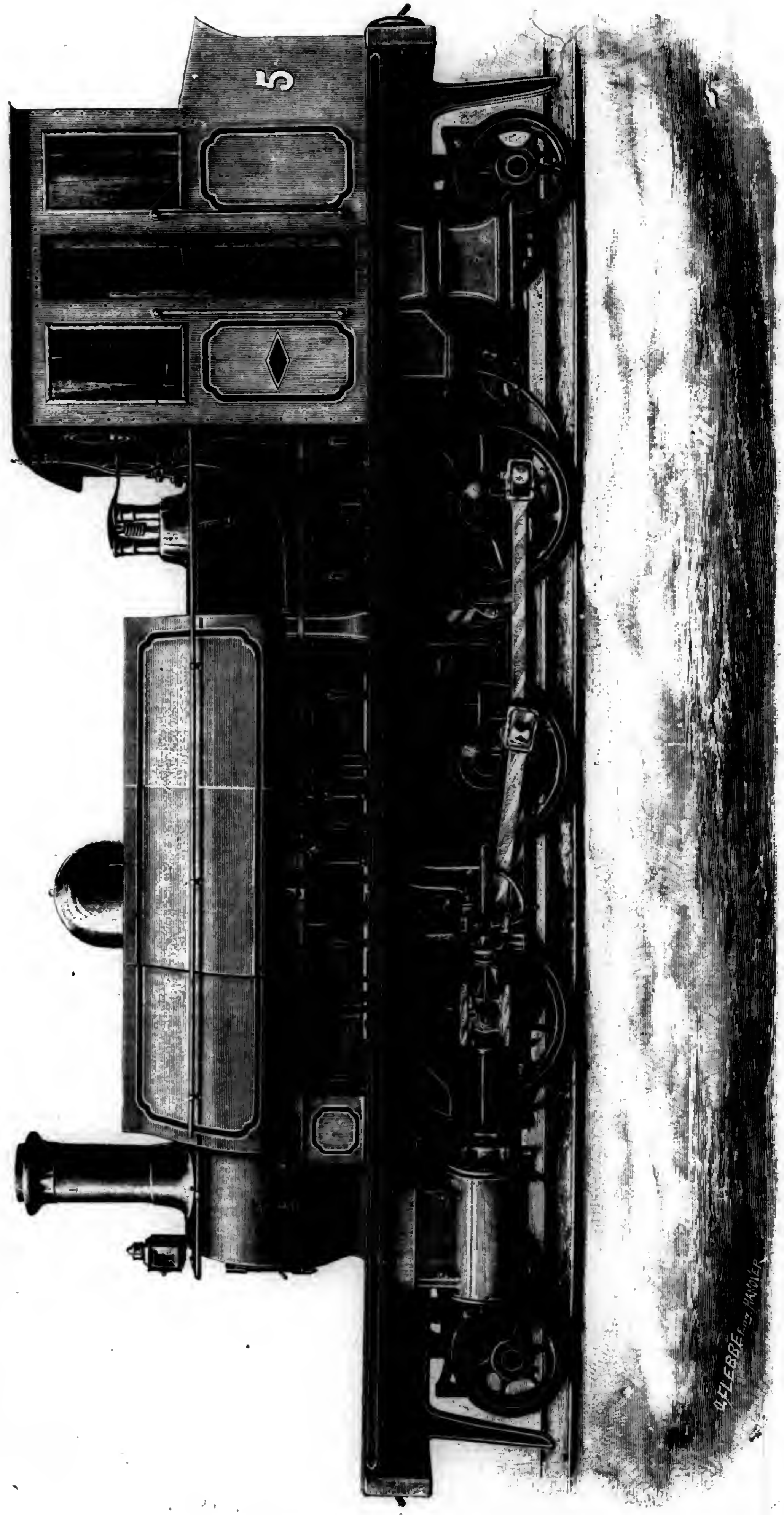
(TO BE CONTINUED.)

Street Railroad Traction in New York.

(From the *Electrical Engineer*.)

It is authoritatively announced that the Third Avenue Surface Railroad Company has definitely determined to commence the work of putting in a cable traction system, for operating its street-car line between the City Hall and Harlem Bridge, as soon as the courts have decided that it may lawfully do so. The estimated cost of the cable plant, which, we understand, is to be similar to that now in use upon the Tenth Avenue line of the same company, is stated to be $1,500,000.

This determination upon the part of the management of such an important street-rail line will doubtless cause some little surprise in electrical circles, especially in view of the rapid advance which has been made during the past year or two in the application of electricity to this class of traffic. Yet upon consideration, it is difficult to see how any other conclusion could have been reached, in view of the fact that it was apparently necessary that some decision should be reached at once. While no well-informed electrical engineer has any doubt that it is entirely feasible to construct and maintain an electric plant of the dimensions required in the present case for less than one-half the sum which will have to be expended upon the cable, yet, at present, it cannot be said that there exists a single electrical establishment in this country which could be depended upon to undertake the work of furnishing equipment for such a line as the Third Avenue, for a fixed sum and to be delivered within a fixed time, and to guarantee its successful and satisfactory operation. Hence it is not to be wondered at that the Third Avenue Company, having an enormous and practically constant traffic which has



TEN-WHEEL TANK LOCOMOTIVE FOR KAIPING RAILROAD IN CHINA.

BUILT BY DÜBS & COMPANY, GLASGOW, SCOTLAND.

outgrown its present facilities, and a line nearly eight miles in length, with almost no curvature—conditions most favorable for the economical application of cable traction—should prefer to adopt it, especially as responsible engineering firms stand ready at any moment to undertake the work.

Nevertheless, we venture the prediction that within five years the managers of the Third Avenue Company will have cause to regret the decision, which under existing circumstances it has practically been forced to make. It would hardly afford the Third Avenue people much gratification to see a parallel line doing the same or even better work with a plant whose first cost and operating expenses were not more than one-half that of their own. Yet the probability that this will come to pass within a very few years is so great that it practically amounts to a certainty. The notion which prevails in some quarters that electricity is less economical when employed on a large scale than on a small one, is an utter fallacy, and should not find credence for a moment among capable electricians. The cable-traction system in practice is a vast improvement over horse-power, a remarkable triumph of mechanical ingenuity and constructive ability; but it is not the final solution of the street-railroad problem, except under very special conditions, such, for example, as those which exist in San Francisco or Kansas City. As our English cousins would say, it is simply a question of *£ s. d.*, and from this point of view the ultimate result cannot be doubtful.

Locomotive for the Kaiping Railroad, China.

THE accompanying cut (from the London *Engineering*) is a general view of one of 10 small ten-wheel tank locomotives now under construction by Dübs & Co., in Glasgow, Scotland, to go to China. The general plan of the engine, with six driving wheels connected and a two-wheeled truck at each end, is shown by the engraving.

These engines, with one exception the first built for regular service in China, are to work on the railroad from the coal mines at Kaiping to the port of Pehtang, at the mouth of the Pei-Ho River. At first this line is to be used for coal exclusively, but it will probably be opened for general traffic later.

A French Criticism of the American System of Train Despatching.

M. ROEDERER, Engineer of Bridges and Roads, and Assistant Superintendent of the Paris, Lyons, & Mediterranean Railroad, who was one of the French railroad officers who last year visited the United States, contributes to the *Annales des Ponts et Chaussées* an article on the movement of trains on the railroads of the United States. This article gives a very fair description of the American system of train despatching, stating facts which are here sufficiently familiar, and closes with the following comments on the American system as compared with that in use in France:

Finally, what is this organization worth? The Americans are proud of it, and consider it the latest step of progress. It is very ingenious, very interesting, and very original. But it is, in my eyes, rather an expedient born of the particular needs of their management than a system to be recommended in itself.

It is necessary to remember that the traffic of the great lines varies enormously from one time to another; that they must constantly provide for conditions suddenly arising, and that, under these circumstances, the rules in force on the French railroad systems would, without doubt, be entirely insufficient. These rules are excellent for a regular traffic, varying but slightly from one season to another from a certain average; but they are less and less excellent as the number of irregular trains increases. If the number of special or wild trains should be increased until it is two or three times as great as that of the regular trains, who can say that our French station officers and trainmen, confused by a service so different from that to which they are accustomed, would not be exposed to serious complications and dangerous lapses of memory?

There is another consideration. Our French rules are not adapted to a train movement at all hurried. One has only to look at a train-sheet to see the gap which a fast train makes among the slower trains which should arrive at a station 15 or 20 minutes before it passes the same point. This effect, easily seen in theory, is still more marked in actual practice, and it is a common thing to see a train held for a long time at a station before it can resume its movement behind the train to which it gave way. As it is necessary to take account in a certain degree of these inevitable delays, the effective capacity of a line is more or less reduced by them.

In the American system it is not so; the despatcher holds all the trains in his hand, he is in constant communication with them, he can put them on a siding at the last moment, can hold them for the shortest period of time, and thus obtain the greatest possible movement.

But while this result is everywhere visible, it can especially be seen on the single-track lines, of which there are still many important ones in America. On such lines in France we could only send out a special train by the aid of a combination of notices which would require several hours' time; or if, in a case of extreme urgency, a train were run by telegraph, it could only move from station to station, stopping at each to get the track clear ahead of it. It would be the same in case of a change in the meeting places of regular trains, or in case a train should be started out of its turn. All this causes much loss of time and reduces largely the number of trains which we can move on a single track.

The American system escapes these inconveniences, and consequently permits of the most complete utilization of the track. Experience shows this fact; we travelled between Buffalo and Chicago on a single-track line 536 miles long, which at the busiest season has an average movement in each direction daily of 10 passenger trains of different speeds and of 30 freight trains, or a total of 80 trains; and there are days when this average is exceeded. On the single-track Pittsburgh, Cincinnati & St. Louis line (over which we did not travel) I am informed that the movement has sometimes reached 75 trains a day in each direction.

These are certainly brilliant results; but whatever American railroad officers may say of them, the system under which they have been attained is not one which could be recommended in France. They have sacrificed, I fear, to the imperious necessity of moving a large number of trains over lines hardly fitted for it, a necessity which we consider still more imperious—that of guarding by the most minute precautions the human lives confided to us. The impression which is forced upon me by this study is that the Americans are imprudent, and others will doubtless agree with me.

But this is only an impression; to decide impartially as to the value of the two systems of train movement, it is necessary to compare them by their results, and to find, by the aid of official figures, how many persons the American railroads and our own have killed and wounded for an equal number of passengers carried one kilometer (passenger-kilometers).

Unfortunately there are in the United States no official statistics on this point, and it is necessary to rely in these matters on a private publication, *Poor's Manual*. This work is very interesting, but its figures must be received with some caution, as they are based entirely on returns furnished voluntarily by the companies. If we consult these returns, in default of more reliable ones, we find that in 1885, on 201,370 kilometers of road then operated, there were 1,837 passengers killed or wounded by accidents to trains. The total number of passenger-kilometers (passengers carried one kilometer) was 15,600,000,000, which gives an average of a passenger killed or injured for each 8,500,000 passenger-kilometers.

On the Paris, Lyons & Mediterranean system the average of seven years, taken from the official statistics collected and published by the Ministry of Public Works, is one passenger killed or injured to each 36,000,000 passenger-kilometers.

Thus in the United States they kill or injure $4\frac{1}{2}$ times as many people as we do in France.

When the very obliging and courteous travelling companions furnished us by the American railroad managements, to whom I am indebted for the information given in this note, were astonished at my want of enthusiasm over their system, it was by these figures that I answered them.

TRIPLE-EXPANSION ENGINES ON LAKE STEAMERS.

[Paper read before the Civil Engineers' Club of Cleveland by Walter Miller. From the Cleveland *Iron Trade Review*.]

THE past year may be regarded as a transition period in the history of the marine engine for lake service, as the high-pressure triple-expansion engine has now proved the successful rival of the compound engine. The object of this paper is to bring before you the result of what little experience the writer has had with this new type of engine, and to try to describe briefly the different designs brought out, as well as that which has a direct bearing on its efficiency.

Some two years ago the writer read a paper before this Club, entitled Compound Engines for Lake Service, and it was then stated that when the triple-expansion engine with its higher steam pressure came into use (as it was certain to do) it would be still more favorable to working steam expansively, and that instead of 10 or 12 expansions, we would have 18 or 20. Little was it expected at that time that less than one year from then the different engineering establishments of the lake marine would be actively engaged in building triple-expansions for the lake service. At the time that paper was read there were no triple-expansion engines being built in this country, and but very few in England and Scotland.

This fact is mentioned here to show that the engineers of the lake marine are awake to the importance of being well up to the times. The first triple-expansion engine was designed by Mr. Kirk at the engineering establishment of George Thompson & Company, near Glasgow, for the steamship *Aberdeen* some three or four years ago. Since then the triple-expansion engine in that country has almost superseded the double compound. In the annals of marine engineering there is no parallel to the rapidity with which these engines came into favor.

On the *Aberdeen* the saving in fuel per voyage was 500 tons, and her carrying capacity was increased by that amount. For ease of working, smooth running, and high piston speed they are not to be compared to any other class of engine built at the present time. It is only a question of time, and that very short, before the quadruple-expansion engine will supersede the triple-expansion engine for lake service.

We may look for high steam pressure and little or no cut-off, but simply expand from one cylinder to the other, with cylinder ratio proportionate to decrease of temperature and increase of volume, avoiding loss or condensation and evaporation. These days one hardly gets familiar with one particular type of engine before there is another brought forward; text-books become obsolete almost before they leave the printers' hands. Imagine, if you please, Bourne's rules for diameter of piston-rod—that is, one-sixth the diameter of cylinder equals diameter of piston-rod—to apply to size of piston-rods for a triple-expansion engine, with cylinder ratio of $2\frac{1}{2}$ to 1. In fact, there are but very few rules to apply to the designing of modern marine engines.

The most important change brought about by the introduction of these engines has been in the valves and valve gear. The old complicated cut-off arrangement has given place to the most simple slide-valves and direct motion. With the high steam used, mainly 150 lbs. per square inch, all the parts of the valve-gear must be well designed. Piston-valves are generally used on the high-pressure cylinders, single-ported slide-valve on the intermediate cylinder, and double-ported slide-valve on the low-pressure cylinder. Some designers think it imperative to use piston-valves on the high-pressure cylinders; and piston-valves have in some instances been used on all the cylinders. It has been found in practice, however, that with good hard iron in both cylinder and valve, slide-valves on the high-pressure cylinder work equally well and are very much cheaper and easier to repair.

Where piston-valves are used on all the cylinders the clearance spaces are excessive, and the steam passages are liable to be cramped, and further, where piston-valves are used throughout, two valves have to be used on the low-pressure cylinder, thereby complicating the valve motion. With the three-cylinder fore and-aft arrangement, it has been quite a problem to design a good valve gear, and has resulted in bringing forward a number of novel devices for reversing and driving the valves; those on the radial motion single eccentric being the more prominent, although the Joy valve and others of that class have been quite extensively used. The Joy valve gear and those of the radial motion single eccentric plan permit the cylinders to be placed fore and aft with steam-chests out in front, making a very convenient engine to get at. But the piston or some balance valve must be used, or else the wear will be excessive. The valve motion described above refers more particularly to those used by Scotch and English engineers, and on nearly all of those built on the coast. But with one exception the link motion has been used on the engines for lake service. The link when well proportioned and correctly suspended has proven the most satisfactory arrangement yet devised to drive the valves on marine engines up to the present time.

A well-known engineer on the coast after using a radial single eccentric motion on two engines declared himself still in favor of the links. It is the practice of the writer's firm, with but one exception, to place the three cylinders in line fore and aft, and slide-valves on all the cylinders (fig. 1); that of the high-pressure on the forward side, the

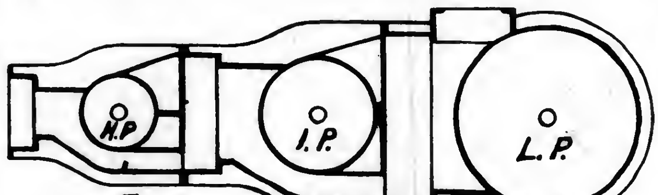


Fig. 1.

intermediate valve between the high-pressure and intermediate cylinders, and the low-pressure valve between the intermediate and low-pressure cylinders; single slide-valve on the high-pressure and intermediate cylinders and double-ported slides on the low-pressure, with link motion to drive all the valves. This arrangement of cylinders and valves admits of six journals in the bed-plate and crank-shaft in three duplicate interchangeable parts. Other builders, however, arrange the cylinders in two different ways: First, with three cylinders in line fore and aft with piston-valve on forward side of the high-pressure cylinder, single slide-valve on the forward side of the intermediate cylinder in separate steam-chest not connected to high-pressure cylinder, and double-ported slide-valve on after side of low-pressure cylinder with link motion to drive all the valves (fig. 2). This arrangement admits of five jour-

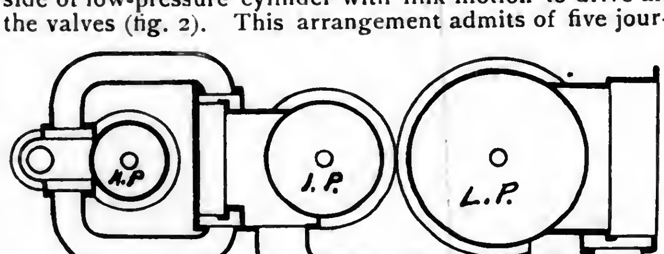


Fig. 2.

nals in the bed-plate and crank-shaft in one or two parts. Second, the three cylinders in line fore and aft; the intermediate cylinder placed forward, and slide-valve and steam-chest on forward side, the high-pressure in the middle, with piston-valve faced out in front and low-pres-

sure cylinder aft with double-ported slide-valve and steam-chest on the after side. The valves for the two outside cylinders—that is, the intermediate and low-pressure, are driven with the link motion and the high-pressure piston valve with Joy valve gear (fig. 3). This arrangement

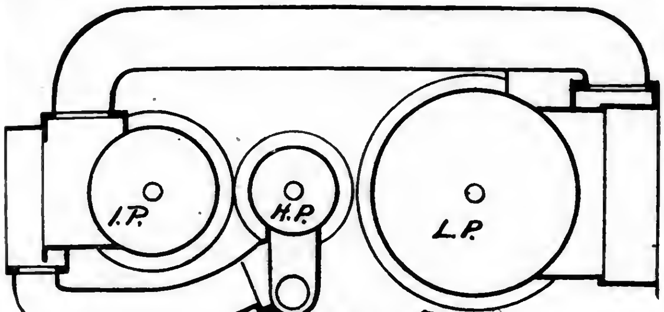


Fig. 3.

of cylinders admits of but four journals in the bed-plate and crank-shaft in one piece. The latter plan would seem the simplest and cheapest, but the design is open to three objections: First, there are two kinds of valve motions requiring two different motions to reverse, and this looks very unmechanical to say the least, although it works well in practice. The second objection is to the journals in the bed-plate, which are four in number, but are two different lengths and all subject to the same wear; therefore, the shortest one would wear down faster than the longer one; then again, the two middle journals, although they are the longest, are not long enough to fill between the cranks, leaving the crank-shaft unsupported close up behind the crank-arms; further, the crank-shaft is built up in one piece with the three throws requiring very careful work and difficult work to handle; besides, it would be very expensive to repair in case of a break-down. The third objection is to the manner of passing the steam from one cylinder to the other. With the high-pressure cylinder in the middle the steam is exhausted from it to the intermediate cylinder on the forward side and exhausted from it to the low-pressure cylinder, which is on the after side of the engine. This arrangement, although it works well, is like placing an engine away from the boiler and supplying it with steam through a long steam-pipe. The second plan mentioned above is that with a high-pressure cylinder placed forward and piston-valves on forward side, the intermediate cylinder in the middle and that of the low-pressure aft, with the valve of the intermediate cylinder placed forward in a separate steam-chest; between it and the high-pressure cylinder also the valve of the low-pressure cylinder on the after side and five journals in the bed-plate with crank-shaft in two parts. This plan costs more than the one with four journals in bed-plate, but is open to about the same objection.

There is an unsightly array of pipes to convey the steam from one cylinder to the other, and on some engines built on this plan the arrangement of journals in bed-plate is very bad. Some of the journals are extremely short, while the journal adjacent to it is more than double the length, making it impossible for them to wear down equally. The shaft, although it is made in two parts, is not in duplicate, consequently is not interchangeable. Shafts thus made have no possible advantage except to facilitate somewhat the building and repairs. Engines built on the first-mentioned plan—that is, with the three cylinders in line fore and aft, with high-pressure forward, the steam-chest on forward side, and the intermediate in the middle, with valve placed on the forward side in a separate steam-chest, formed by bolting the high-pressure and intermediate cylinders together, the low-pressure placed aft and the valve on the forward side in a steam-chest formed by bolting the intermediate and low-pressure together, although the most expensive are on by far the more mechanical plan and conducive to the best economy. The exhaust is conveyed from one cylinder to that of its fellow in the shortest possible manner by an exhaust belt cast on the side of cylinder almost in a straight line; and when lagged up it has a symmetrical look about it that is not seen in any of the other designs. Access is had to the valves by covers placed on top of the steam-chest. As mentioned before, there are six journals in the bed-plate, all of equal length, and all things being equal, should wear down alike. The crank is in three duplicate interchangeable parts, therefore making a very simple crank to build and repair. With this same arrangement of journals and crank-shafts the valve gear is brought in line with the valves without any off-sets or bent eccentric rods. What would have been a very pleasing design to the eye many times has been marred by a bent eccentric rod, aside from the mischievous way they have of dodging their work.

There is another design of triple-expansion engine that is considered the simplest and cheapest to build, but does not seem to take as well—that is, those that have two cylinders in line fore and aft, the intermediate and low-pressure, with the high-pressure placed on top of the intermediate cylinder (fig. 4). The principal objection to this

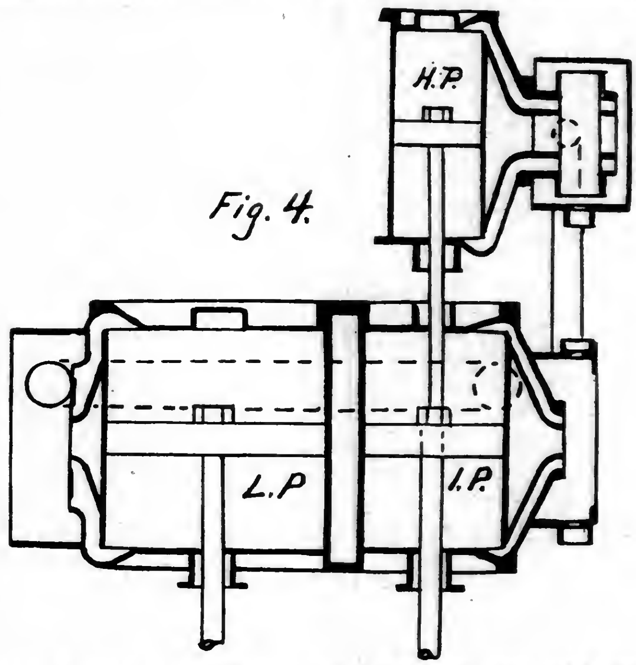


Fig. 4.

plan is that it throws too much work on one crank-pin, making a very unequal strain on the crank-shaft, and, you may say, all of the other working parts of the engine. There has been to the writer's knowledge but one engine built on this plan for the lake service. Although it worked well and gave every satisfaction, it did not seem to attract the attention that the others did built on the three-cylinder, fore-and-aft plan.

Since the triple-expansion engine came out it has been the aim of designers to so proportion the cylinders that the work done in one will be about equal in each, thus equalizing the fall of temperature. In some cases the H.P. developed would not vary more than 3 to 5 in each cylinder, but this equalizing of power has been assisted by the sliding blocks in the reverse arm lengthening out or shortening the valve travel. It would seem the better way to so proportion the cylinder valves and size of receiver space that the work done in each cylinder would be equal, and by notching up with the reverse gear vary the range of expansion rather than trust the engineer to adjust the valve travel to equalize the work done in each cylinder. The exact ratio of cylinder is not an arbitrary matter requiring deep mathematical study. The distance from center to center, arrangement of valves, steam-chest, and receiver spaces, as well as crank sequence, should be taken into account, as they affect the cylinder ratio very materially. Too large receiver space between cylinders would result in fall of pressure and lower temperature. Crank sequence or order of following is best arranged by taking into account the arrangement of cylinders.

The writer's experience so far has been with the low-pressure leading, intermediate following, and the high-pressure last; but with the present plan of cylinders—as the receiver spaces are rather large—it would be better it

the high-pressure crank was leading, intermediate following, and low-pressure last. With the former order of following, the back pressure would be through one-sixth of the revolution, while the latter order following the back pressure would be through one-third of the revolution; the increase of back pressure in this case would result in bringing up the initial pressure and equalizing the work done in the after cylinder.

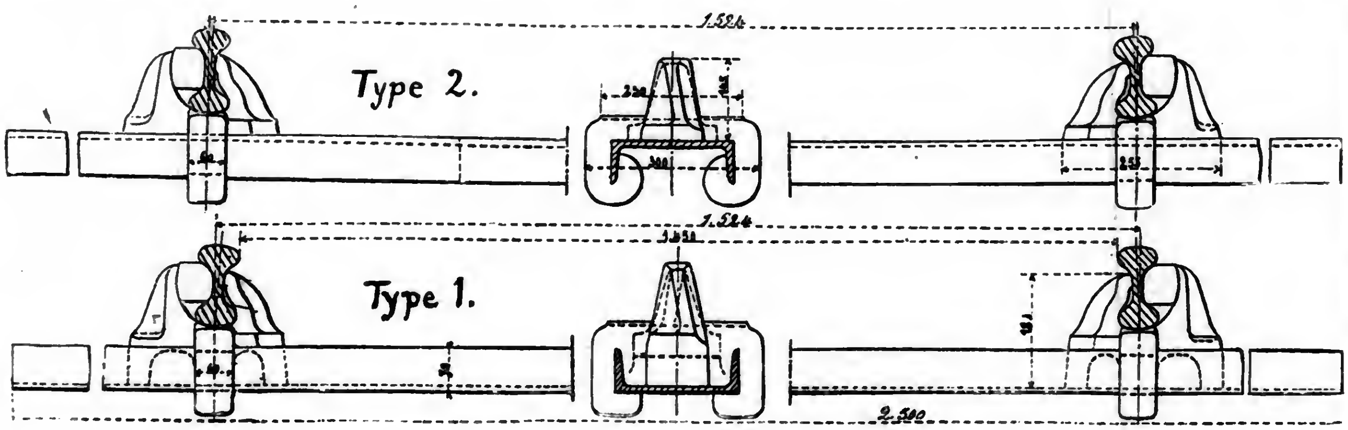
The three-throw crank-shaft for the triple-expansion engines built by the writer's firm is of the built-up class, and requires very careful and accurate work in boring, fitting, and shrinking to insure its alignment when bolted together in place. The bed-plate is first fitted with the six pairs of journal brasses and a large boring-bar is run through, and all of the six journals are bored out at once; then a truing mandril is used to scrape the journals down to a bearing. The six pieces of shafts with couplings forged on all turned down to size, and the crank-arms shrunk on and keyed, are then placed in the bearings and fitted with distance pieces between the crank-arm; then bolted firmly together, with the eye of the crank-pins in line. The same bar that is used to bore the bed-plate journals is then run through, and the three pairs of crank eyes are bored at once. A portable furnace is then placed over each pair of cranks separately, and the cranks brought up to the proper heat for shrinking; the furnace is then cleared away, and the crank-pins which have been turned down to the finished size are then shoved in place and left to cool. Each part of the crank-shaft is then put in the lathe and about $\frac{1}{64}$ in. turned off the journals, and the couplings faced up. The holes for the coupling bolts are drilled by templet, and the bolt-holes are reamed after the cranks are in place. Each part of the crank is in duplicate and will interchange, thus lessening the delay in case of a broken crank.

The increased steam pressure carried with the new engines has resulted in the abandonment of the old return tubular fire-box boiler, so long in vogue for the lake service. With such large crown sheets and flat-stayed surfaces, it was impracticable to continue their use, and led to the adoption of the boiler which is commonly called the Scotch boiler, with circular furnaces and return tubes. The furnaces are either corrugated or else flanged in short lengths with rings between the flanges. Boilers on this plan are now being made for the lake service 14 ft. in diameter by 12 ft. long, with steel shell plates $1\frac{3}{32}$ in. thick, to carry 160 lbs. of steam per square inch. The shell plates are all drilled and double-riveted by hydraulic riveters, as it would be almost impossible to make these boilers tight by hand riveting. Heavy machinery for riveting, bending, flanging, and drilling these plates for the building of these boilers has had to be added to the boiler-building plants on a scale little thought of two years ago.

As yet nothing has been mentioned as regards the economy of the triple-expansion engine for lake service. As was intimated at the beginning of this paper, the writer had been waiting for some data to compare with the compound engine, and therefore can only say that they have shown a very marked economy; but as to how much he is not able to give any figures. When lake freights are booming, as in the season just closing, 20 to 30 tons of coal a trip is not much of an object, and vessels that can carry and have plenty of power to push them through the water are made to go; but for smooth working, ease of turning, and high piston speed they have been a success.

FRENCH METALLIC RAILROAD TIES.

The Western Railroad Company of France has been for some time using metallic ties of the forms shown in the accompanying engravings. The two forms, types 1 and 2, are the same, except in one important particular. In type 1 the channel-bar, which forms the greater part of the tie, has its flat side down, while in type 2 the flat side is up, the angles of the channel-bar entering the ballast. The results are given as follows by M. Jules Morandiere, Engineer of Material for the Company:



METALLIC TIES USED ON WESTERN RAILROAD OF FRANCE.

(Dimensions in meters and millimeters.)

Experience with the two types of ties shown has proved that the tie of type 1 should be used, because it beds itself well in the ballast, and because it is, in relation to stability, under the same conditions as a wooden tie.

The tie (type 1) consists of an iron channel-bar placed with the flat side down, upon which the chairs are *cast*; these chairs being of such a form that only one key is required. The weight of the tie is about 286 lbs., the iron tie proper weighing 163 lbs., and the castings 123 lbs.

The perfect welding of the castings to the iron channel-bar can be obtained in several ways. M. Chassée, who made the first ties in his factory at Mans, has taken a patent for the method which he uses.

The chairs shown in both types are designed for a double-head rail. No special design has yet been made for a tie to suit rails of the Vignoles pattern, although the company has about 1,180 miles of track with rails of that pattern. But in the opinion of this company the use of a chair interposed between the rail and the tie is necessary for the Vignoles as well as for the double-head rail on all lines where there are sharp curves or many grades. Already chairs have been put under about 249 miles of its line where the Vignoles rail is used. Under these conditions the metallic tie, if used with that type of rail, would differ from type 1, as here shown, only by a slight change in the form of the chair.

CATECHISM OF THE LOCOMOTIVE.

(Revised and enlarged.)

By M. N. Forney.

(Continued from page 576, Vol. LXI.)

CHAPTER VI.

THE SLIDE-VALVE.

Question 102. *How is an ordinary slide-valve constructed?*

Answer. The general construction of a slide-valve was explained in answer to question 67. Such a valve is represented by figs. 49 and 50, fig. 49 being a section and fig. 50 a plan.

Question 103. *What is meant by the lap of a valve?*

Answer. The "*lap*" of a valve is that portion of it which

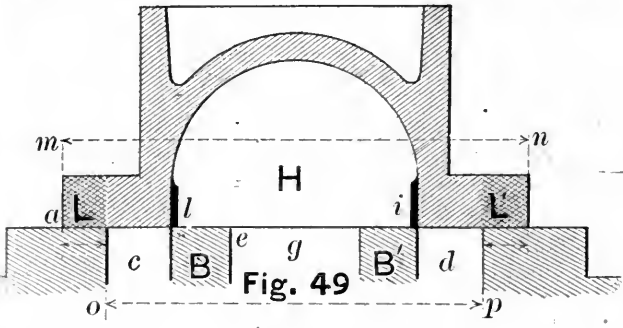


Fig. 49

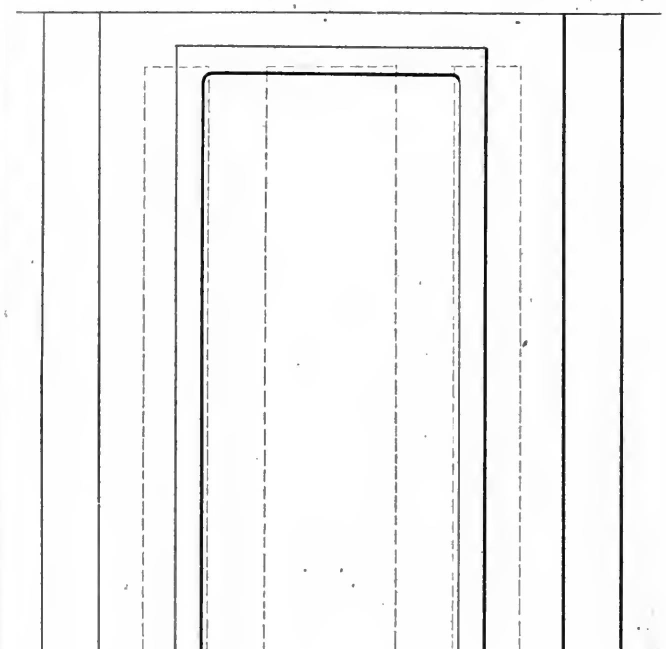


Fig. 50

overlaps the steam-ports, when it stands midway over the valve-face. Thus in fig. 49 the parts *L L'*, shaded with cross lines, and which overlap the outside edges of the steam-ports *c* and *d*, form the "*outside lap*" of the valve; and the parts *l l'*, shown in black, which overlap the inside edges of the steam-ports, form the "*inside lap.*" Ordinarily in speaking of the "lap" of a valve it means the outside lap.

Question 104. *What is meant by the "lead" of a valve?*

Answer. "*Lead*" means the width of the opening of the steam-port when the piston is at the beginning of its stroke. Thus if the valve *H*, fig. 51, stood in the position shown, when the piston is at the end of the cylinder, and the piston is at the beginning of its stroke, the opening *a* of the steam-port *c* would be the lead. The opening of the port on the outside of the valve is called *outside lead;* on the inner or exhaust side, as shown at *b*, it is called *inside lead.*

Question 105. *What is meant by the "travel" of a valve?*

Answer. By the "*travel*" we mean the distance that the valve is moved back and forth, or, in other words, its stroke. In an engine like that shown in Plate I, if the rocker arms are both of the same length, the travel of the valve will be equal to the throw of the eccentric.

Question 106. *What are the essential conditions which a slide-valve must fulfil in governing the admission and exhaust of steam to and from the cylinder of an ordinary engine?*

Answer. 1. It must admit steam to one end only of the cylinder at one time, so that the pressure, which moves the piston, will not be exerted on both sides of it at the same time.

2. It must cover the steam-ports so as not to permit steam to escape from both steam-ports at once.

3. It must allow the steam to escape from one end of the cylinder *before* it is admitted to the other end, so as to give the steam, which is to be exhausted, time to escape before the piston begins its return stroke.

4. It must not allow "live steam" * to enter the exhaust-port from the steam-chest.

5. In order to utilize the expansive force of the steam, the valve must close each steam-port on the outer or steam side before it is opened on the exhaust side.

Question 107. *How does the valve shown by figs. 49–51 fulfil these conditions?*

Answer. 1. The lap on the outside of this valve being greater than that inside makes it impossible to open either one of the

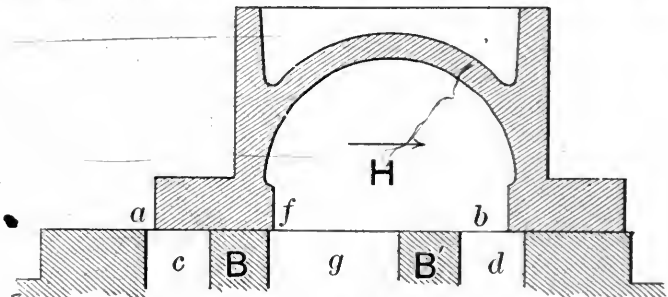


Fig. 51

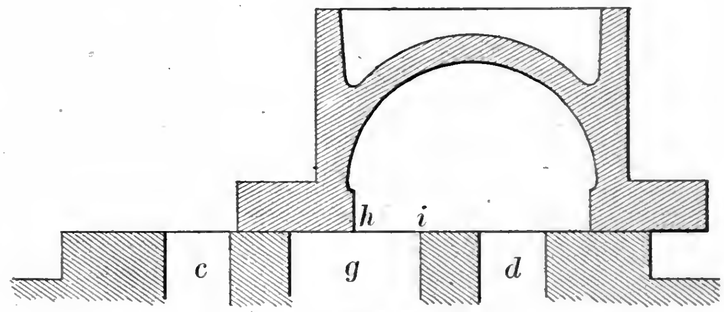


Fig. 52

steam-ports for the admission of steam, until *after* the other port is opened to the exhaust. Thus the valve cannot be moved from the position shown in fig. 49 to that shown in fig. 51, so as to open the port *c* at *a*, without first opening the port *d* at *b*, which allows the steam in *d* to escape into *g*. The outside width of the valve, as indicated by the dotted line *m n*, fig. 49, is greater than the distance over the outside edges of the steam-ports—shown by the dotted line *o p*—so that it is manifestly impossible for the valve to uncover both steam-ports, and thus admit steam into each at once.

2. The width of the exhaust cavity *H* in the valve, measured from *l* to *l'*, is less than the distance over the inner edges of the steam-ports *c* and *d*—consequently, these ports cannot both communicate with the exhaust cavity simultaneously.

3. If the valve shown in fig. 51 is moving in the direction indicated by the dart at *H*, it is obvious that the steam-port *d* will be opened to the exhaust at *b* before the port *c* will be uncovered at *a* for the admission of steam. The same action will occur when the valve moves in the opposite direction, and, as already pointed out, is due to the fact that the outside lap is greater than that inside.

* By *live steam* is meant steam which has been taken direct from the boiler, and which has not been expanded in the cylinder. The term is used in contradistinction to steam which has been admitted to the cylinder, and by the exertion of its expansive force has done work on the piston.

4. Live steam cannot enter the exhaust-port unless it should be uncovered by the valve. This cannot occur unless the valve, fig. 49, should move far enough so that its edge *a* will pass beyond the edge *e* of the exhaust-port. For this reason half the travel of the valve must always be less than the widths of the lap *L*, the steam-port *c*, and the bridge *B* * added together.

5. It will be plain that if the valve shown in fig. 51 is moving from right to left, or in the reverse direction to that indicated by the dart *H*, that the opening *a* will be closed before the port *c* is opened on the exhaust side, as the width *a f* of the valve is greater than the width of the steam-port.

QUESTION 108. *What other point must be observed in proportioning a slide-valve and the steam-ports for it?*

Answer. The exhaust-port must be made of such a width that when the valve is at the end of its travel the opening of the —as it always is in well-proportioned slide-valves—it causes the exhaust-port at one end of the cylinder to be opened before the steam-port at the other end is uncovered to admit steam. This is shown in fig. 35, from which it will be seen that if the valve is moved in either direction one of the steam-ports will always be opened on the exhaust side of the valve before it is opened to admit steam to the cylinder.

QUESTION 111. *What is the object in giving a slide-valve lead?*

Answer. It is done so that the steam-port will be opened for the admission of steam a little before the piston reaches the end of its stroke, so that there will be a cushion of steam to receive the piston and reverse its motion at the end of the stroke. Another advantage which lead gives is that it results in the steam-port being wider open when the piston begins its return stroke than it would be if there were no lead.

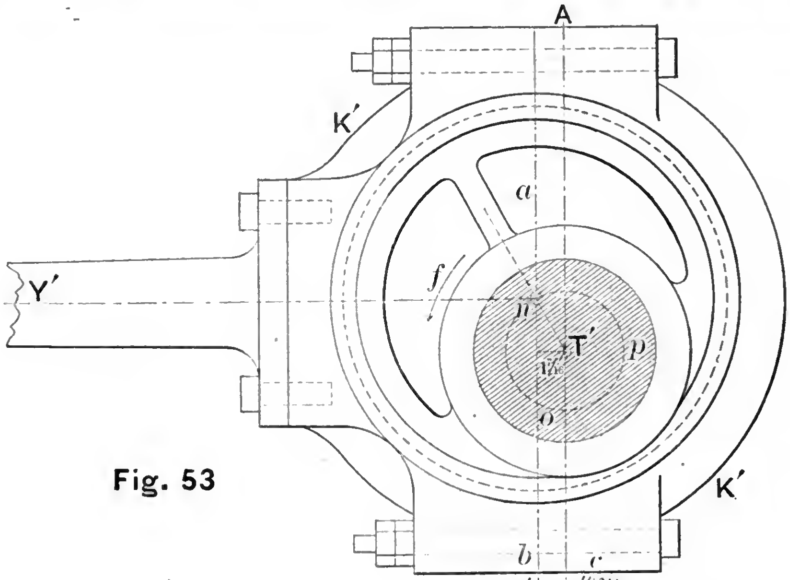


Fig. 53

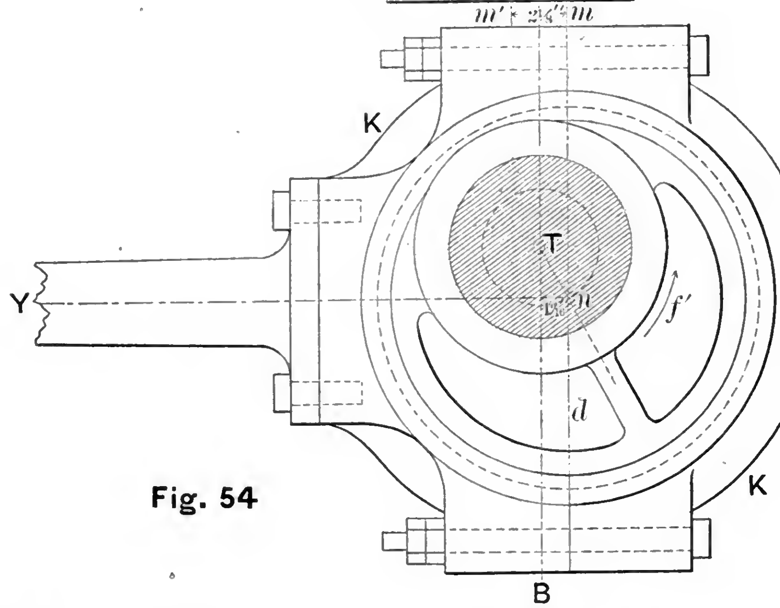


Fig. 54

port will be wide enough so as not to choke or "*throttle*" the exhaust steam. Thus in fig. 52 the valve is represented in the position it occupies at one end of its travel. The point which must be observed is, that when it is in this position the opening *h i* must be sufficiently wide for the free escape of steam from the port *d*.

QUESTION 109. *How does the lap of a valve cause the steam to act expansively?*

Answer. When a valve has an outside lap, as was explained in answer to question 80, those portions of its face which cover the steam-ports, being wider than the ports, occupy some time in moving over them, during which time the steam is enclosed in the cylinder, as there is then no communication either with the steam-chest or the exhaust-port. This action of the valve is due to its lap.

QUESTION 110. *What other good effect results from the outside lap of a slide-valve?*

Answer. If the outside lap of a valve is greater than that inside

* The metal *B*, between the steam and exhaust-port, is called a *bridge*.

QUESTION 112. *What effect do lap and lead have on the release or exhaust of the steam?*

Answer. They cause the steam to be exhausted earlier in the stroke than it would be if there were no lap or lead. They also cause the steam-port to be closed on the exhaust side before the piston completes its stroke, the advantage of which will be explained hereafter.

QUESTION 113. *How is the motion imparted to a slide-valve which will make it fulfil the conditions which have been explained?*

Answer. In the answers to questions 68, 69, and 70 the general construction and action of an eccentric was described, but to make these still plainer, figs. 53 and 54 have been drawn showing an eccentric in two opposite positions, or as it would appear before and after the shaft has made half of a revolution.* In fig. 53 it is represented in the same position that it

* Figs. 53 and 54 are drawn to a scale just one half that of figs. 49 to 52—that is, figs. 49 to 52 show the valve one quarter its full size, whereas the eccentric is represented only one eighth of its full size.

occupies in fig. 15—when the piston is at the beginning of its stroke, and the valve is in the position shown in fig. 51, and has $\frac{3}{16}$ in. lead at *a*. In fig. 49 the valve is shown in the middle of the valve-face, and, as already explained, in fig. 51 it has moved from its middle position a distance equal to the lap $\frac{7}{8}$ in. and lead $\frac{3}{16}$ in., or $\frac{7}{8}+\frac{3}{16}=1\frac{1}{16}$ in. Consequently when the piston is at the beginning of its stroke and the valve is in the position described and shown in fig. 15, the eccentric must be in a corresponding position—that is, it must be $1\frac{1}{16}$ in. from the middle of its throw. In figs. 53 and 54 T' and T are the centers of the shafts, $A\ B$ is a vertical center line drawn through these centers, and n' and n are the centers of the eccentrics. The valve, it will be seen from figs. 15 and 51, is on the *right* side of its middle position, therefore, as the motion of the eccentric is reversed by the rocker, the center of the eccentric must be on the *left* side of the middle of its throw. As the center n' of the eccentric revolves around T', the center of the shaft, obviously n' moves an equal distance on each side of the vertical line $A\ B$. It has been explained in another place that the eccentric and its strap $K'\ K'$ are always turned so as to fit each other accurately. Consequently, the center n' of the eccentric always coincides exactly with that of the strap, and, as the distance from the center n of the strap, fig. 14, to the center of the pin at the other end of the rod L always remains the same, if we know the position of the center of the eccentric, we can always know that of the pin at the other end of the rod, which will show the movement imparted to the rocker and by it to the valve. Therefore, in studying the action of an eccentric all that we need concern ourselves about is the movement of its center in relation to that of the shaft.

ment of the center of an eccentric shows the motion imparted to the strap and rod. All that is needed, therefore, is to draw circles which will represent the path in which the center of the eccentric revolves, and then lay out the position on these circles that the center would occupy during a whole revolution of the crank. But before describing how this is done, it will be necessary to give an answer to the following question:

QUESTION 117. *How can the position of the crank and eccentric be determined for any position of the piston?*

Answer. This can be done by the aid of the diagram fig. 55. Before describing the method of doing this, it should be explained first that the cross-head and piston, being rigidly connected together, their motion coincides exactly. We may therefore disregard the piston for the present, and simply observe the movement of the pin on the cross-head in relation to the crank. The large circle shown by a full line in fig. 55 represents the path of the center of the crank-pin, and is divided into degrees. The small circles 0, 4, 8, 12, 16, 20, and 24, on the left-hand side, represent the successive positions of the cross-head pin corresponding to those shown in figs. 15 to 21. The length of the connecting rod, 7 ft., is the distance from 0 to *a*, or from 12 to the center *T*. By taking this length in a pair of dividers, and with 4 as a center, if we intersect the circle with a small arc at *b*, it will give the position of the crank-pin when the piston has moved a distance equal to that from 0 to 4, or 4 in. of the stroke. With a connecting-rod of the length given, 7 ft., and 24 in. stroke of piston, it will be found that while the latter has moved 4 in. the crank has turned through 45 degrees of a complete revolution. In other words, a line *b T*, drawn through the center *b* of the crank-pin, and the center *T* of the shaft, will

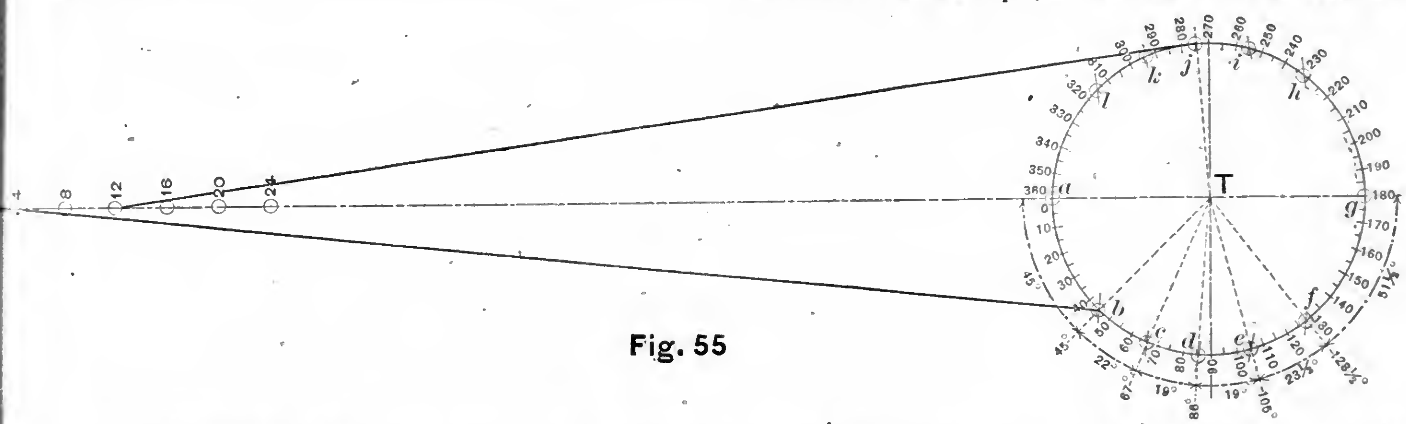


Fig. 55

It has been explained that, in the example given, the valve, at the beginning of the stroke of the piston, must be $1\frac{1}{16}$ in. from its middle position on the valve-face. The center of the eccentric must therefore be the same distance from the middle of its throw. Consequently, if we draw a vertical line $a\ b$, $1\frac{1}{16}$ in. from $A\ B$, the center of the eccentric must be on the line $a\ b$, and, as the eccentric has $4\frac{1}{2}$ in. throw, if we draw a circle $n'\ o\ p$, $4\frac{1}{2}$ in. diameter, with T' as a center, the center of the eccentric will also be on this circle, and therefore it must be at the point where the line $a\ b$ and the circle $n'\ o\ p$ intersect each other.

As $a\ b$ has two points of intersection, n' and o, we must take that one which will move the valve in the right direction.

QUESTION 114. *How can we know in which position the center of the eccentric should be placed?*

Answer. This can easily be determined if we know which way the crank is turning and the position of the piston. Thus in fig. 15 the dart N indicates the direction that the crank is turning, and the piston is represented at the front end of the cylinder. Obviously the front steam-port must then be opened to admit steam in front of the piston to force it backward, and the valve must be moved toward the right-hand side. As the motion of the eccentric is reversed by the rocker, the center of the eccentric must move toward the left-hand side. In fig. 53 the dart f shows the direction of revolution of the shaft—the same as N in fig. 15. It will be evident from the engraving that if the center of the eccentric is located at n', that it will move toward the left-hand side, whereas if it was at o it would move toward the right-hand side when the shaft turns in the direction shown by the arrow f.

QUESTION 115. *What does fig. 54 show?*

Answer. In fig. 54 the shaft and eccentric are represented as having made a half revolution from the position shown in fig. 53. Consequently the center n is on the right-hand side of the line $A\ B$, and as far from it as it was in fig. 53.

QUESTION 116. *How can the action of an eccentric be shown in the most simple way?*

Answer. As explained in answer to question 113, the move-

form an angle of 45 degrees with the center-line $a\ T$. As the crank, shaft, and eccentric are all rigidly connected together, if the one turns 45 degrees of a revolution, the others must turn equally as much. We will now draw a circle, $n\ o\ p$, fig. 56, representing the path or throw of the eccentric, and its center n will be laid down in the position it occupies when the piston is at the beginning of its stroke, as shown in figs. 15 and again in 53, and we will draw a line $a\ T$ through the center n of the eccentric and T of the shaft. A similar line will also be drawn in fig. 57. From what has been said it is obvious that while the crank is turning from the position shown in fig. 15 to that shown in fig. 16, or from a to b in fig. 55=45 degrees, that the eccentric must also have turned an equal amount. Therefore, if from the line $a\ T$ in fig. 57 we lay off an angle $a\ T\ b$, $= 45°$ the intersection of the line $b\ T$ with the circle will represent the position of the center of the eccentric when the piston has moved 4 in., or is in the position shown in fig. 16, and the crank is in the position shown at b in fig. 55.

Returning again to fig. 55, let it be supposed that the piston has moved 8 in. We will take the center of the small circle 8 as a center and the length of the connecting-rod as a radius, and intersect the large circle with a small arc at c. It will then be found that in moving from a to b that the crank has turned 22 degrees. Proceeding as before, the line $b\ T$ will be laid down in fig. 58 in the same position as in fig. 57, and an angle $b\ T\ c$, equal to 22 degrees, will be laid off from $b\ T$. Then the intersection of $c\ T$ with the circle at n will be the position of the center of the eccentric when the piston has moved 8 in. of its stroke.

In this way we may proceed and lay out the position of the eccentric for each position of the piston shown in figs. 15–22, or for the corresponding position of the crank represented by *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *j*, *k*, and *l* in fig. 55. This has been done in figs. 56 to 69, and if the reader will draw a similar series of diagrams it will probably give him a clearer idea of the action of an eccentric than he can get in any other way.*

* In drawing such a series of diagrams, it will be best to make them to a larger scale than they are represented in the engravings.

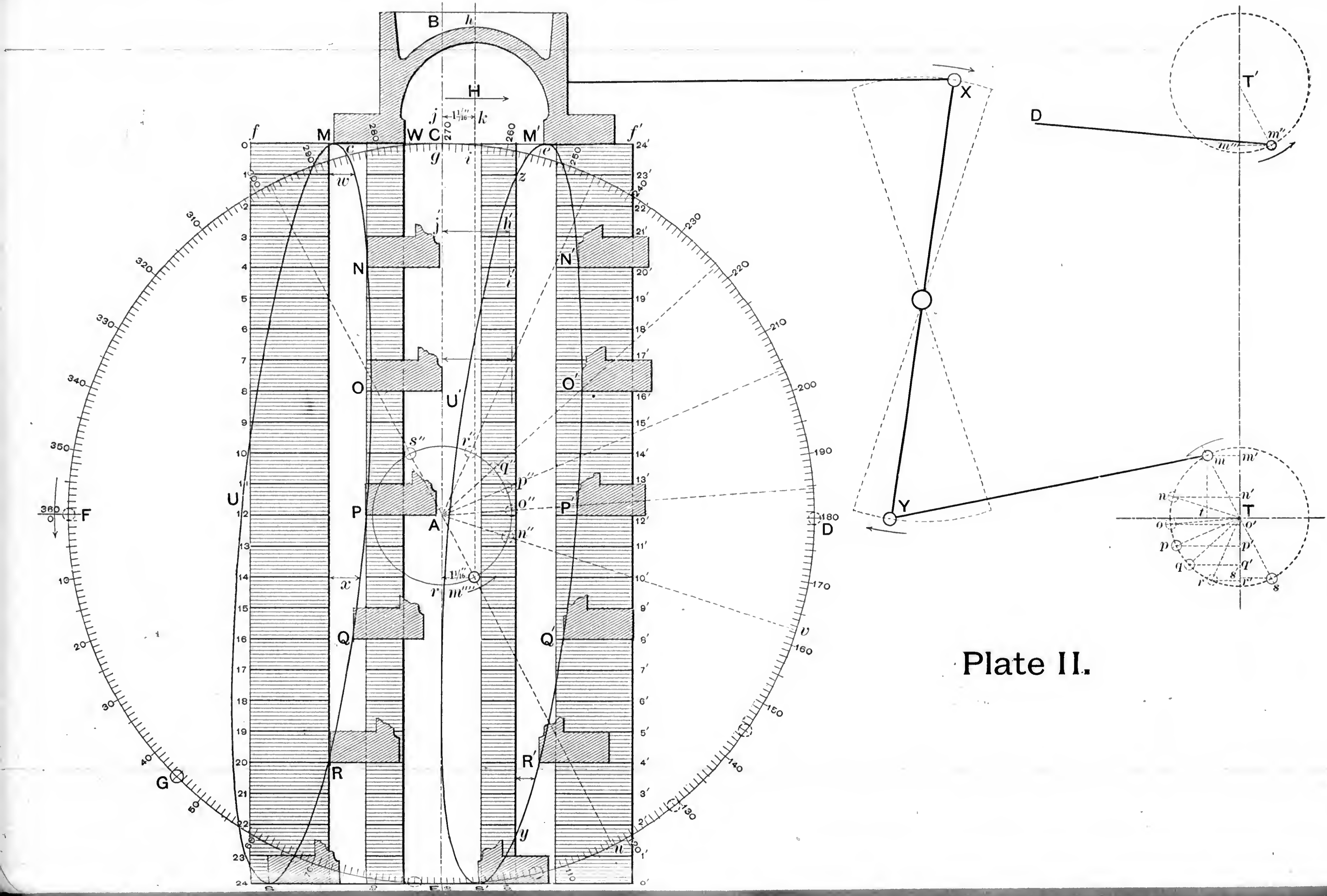


Plate II.

QUESTION 118. *How can the movement and the action of a valve be shown most perfectly on paper?*

Answer. By drawing a diagram—that is, by representing the valve in a number of the positions it occupies in relation to the steam-ports during a complete stroke of the piston, and then drawing what are called *motion curves* through the inner and outer edges of the valve in each one of the positions in which it is represented. As such curves are in a sense purely imaginary, and do not represent any object on an engine, it is difficult to explain clearly their nature and purpose, and perhaps still harder for those with little or no knowledge of drawing to understand an explanation, no matter how clearly it may be written. The reader must, therefore, expect to give close attention and perhaps some hard study to the following description of this method of showing the movement of a slide-valve, in relation to that of the piston and crank, and to the steam and exhaust-ports:

It will be supposed, in the first place, that the horizontal line ff', Plate II, represents the valve-face, and H a valve with $\frac{7}{8}$ in. outside lap. c and e are the steam-ports $1\frac{1}{4}$ in. wide, and g the exhaust-port $2\frac{1}{2}$ in. wide, the bridges between being $1\frac{1}{8}$ in. thick. The valve H is represented in the position it would occupy when the piston is at the front end of the cylinder, and at the beginning of its stroke, the valve having $\frac{3}{16}$ in. lead at M. $B\ E$ is a vertical center line through the valve-face and exhaust-port g. $h\ i$ is the vertical center line of the valve. As the lap is $\frac{7}{8}$ and the lead $\frac{3}{16}$, the distance $j\ k$ between the center line of the valve and that of the face must be $\frac{7}{8}+\frac{3}{16}=1\frac{1}{16}$ in.* Let $X\ Y$ represent a rocker, T the center of the main shaft, and the dotted circle around it the path of the center m of the eccentric, which has $4\frac{1}{2}$ in. throw. The rocker and eccentric, to save room in the engraving, are both represented nearer to the valve-face than they would be on an engine. The position of the piston, crank, etc., are supposed to be the same as shown in fig. 15. The dart H shows the direction in which the valve is moving, and the one at m the way the eccentric is revolving. As the valve should be $1\frac{1}{16}$ in. from its central position at the beginning of the stroke, and the rocker-arms being of equal length, obviously the center m of the eccentric must also have moved the same distance, $m\ m'$, from the vertical line $m'\ r'$ drawn through the center of the shaft. Therefore, if we draw a vertical line $m\ t$ parallel with $m'\ r'$ and $1\frac{1}{16}$ in. from it, as already explained, its intersection m with the dotted circle will be the location of the center of the eccentric, when the piston is at the beginning of the backward stroke, and the valve is in the position shown at H.

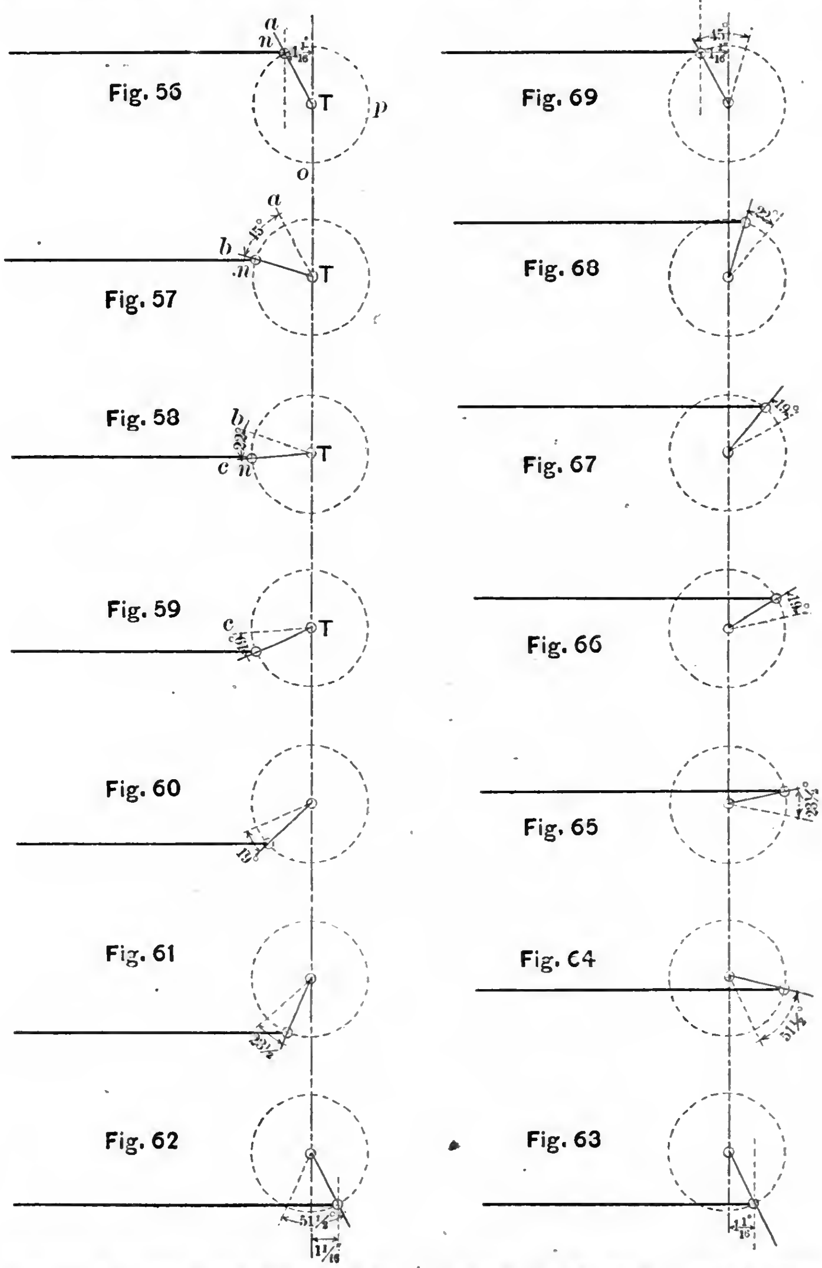


Fig. 56, Fig. 57, Fig. 58, Fig. 59, Fig. 60, Fig. 61, Fig. 62, Fig. 63, Fig. 64, Fig. 65, Fig. 66, Fig. 67, Fig. 68, Fig. 69

It will now be supposed that the piston has moved 4 in., or into the position shown by fig. 16. In doing so it will be seen that the crank has turned a certain distance from the dead point shown in fig. 15 to the position represented in fig. 16. It has been explained that this angle—with a connecting-rod and stroke of piston of the dimensions given—will be 45 degrees. Therefore, if we draw a line, $m\ T$, through the center of the eccentric and the center of the shaft, and draw another line, $n\ T$, through T, and at an angle of 45 degrees to $m\ T$, its intersection, n, with the dotted circle will represent the position of the center of the eccentric, when the piston has moved 4 in. from the dead point.

The effect of this movement on the valve can easily be fol-

* The reader is recommended to lay out the steam-ports on a strip of cardboard or wood, and the valve on another, full size. By sliding the valve on the valve-face, as described herein, he will be able to understand the description better than he can without such an illustration before him.

lowed if the reader will observe the direction of the motion indicated by the darts at *m*, *Y*, *X*, and *H*. It will be noticed that when the center of the eccentric is at *n*, its distance *n n'* from the vertical center line is greater than when it was at *m*. The horizontal line *m m'* is equal to the distance $j\ k = 1\frac{1}{16}$ in. between the center line of the valve and that of the valve-face. *n n'* shows the distance between these center lines when the piston has moved 4 in. of its stroke. If, therefore, we draw the valve, with its center-line, a distance equal to *n n'* from the middle of the valve-face, it will be in the position it occupies when the piston is in the position shown in fig. 16. If we drew it in

the line 4 20',* with *h' i'* as its center, which shows it in the position it will occupy in relation to the steam and exhaust ports when the piston has moved 4 in. of its stroke, as shown in fig. 16.

We can now proceed in the same way to show the position of the valve on the line 8 16' when the piston has moved 8 in. of its stroke, as represented in fig. 17. It has been shown from fig. 55 that when the cross-head pin has moved 8 in., that the crank has turned through 22 degrees of a revolution from *b*, or 67 degrees from the dead point *a*. If, then, we draw a line *o T* on Plate II at an angle of 67 degrees with *m T*, its intersection

Fig. 70

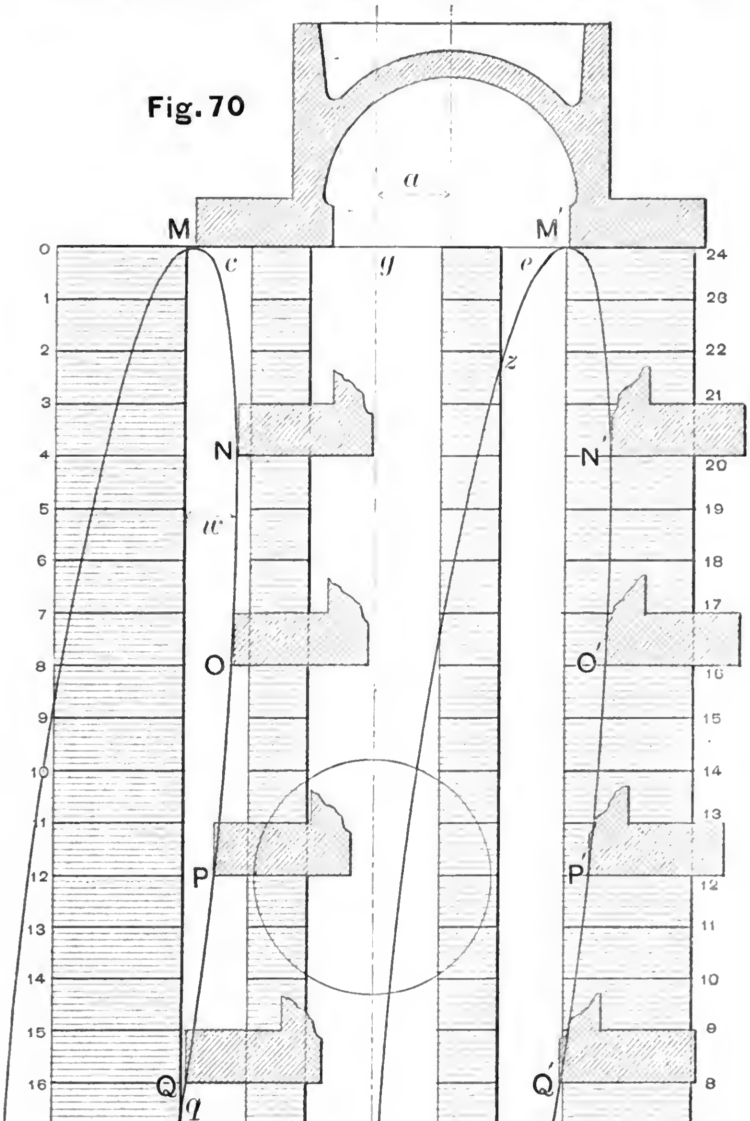
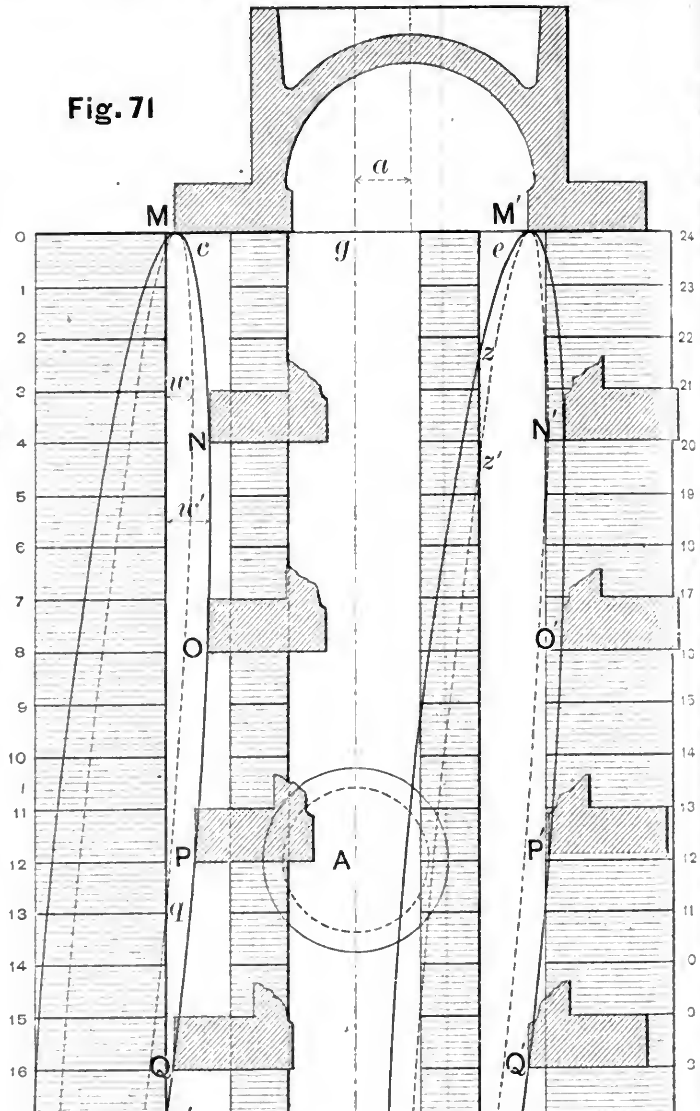


Fig. 71



this position on the line *f f'*, the drawing would be liable to be confused with the valve already represented there. To avoid such confusion another line 4 20' has been drawn a distance equal to the movement of the piston, 4 in., below *f f'*, and on this line a perpendicular *h' i'* has been laid down at a distance *j' h'*, equal to *n n'* from the center of the valve-face. *h' i* will then represent the center of the valve in its new position. The edges of the ports *c g* and *e* have been extended downward, and the lower part of the valve has been drawn on

with the dotted circle will be the position of the center of the eccentric when the piston is in its new position. The center of the eccentric is therefore a distance *o o'* from the center line *m' r'*, which indicates the movement of the valve. For the reason already explained—that is, to avoid confusion in the

* To avoid too much confusion, in the diagram only the edges of the valve, which control the admission and exhaust of steam, are represented in its successive positions.

diagram, the valve will be represented in its third position on the line 8 16′, and it will be laid off as before.

Proceeding in the same way, the positions *p*, *q*, *r*, and *s* of the center of the eccentric, when the piston has moved 12, 16, 20, and 24 in. of its stroke, may be laid down in Plate II. The edges of the steam and exhaust-ports and the center line *g E* are extended downward, and the line *C E* is made equal to the stroke of the piston. Horizontal lines 8 16′, 12 12′, 16 8′, etc., are drawn at a distance from *f f′* equal to the movement of the piston. The different positions of the valve indicated in figs. 15 to 21 are then laid down on these lines.

We now have a graphical representation of the movement of the valve in seven successive positions of a stroke. The position of the outer edge of the valve, which controls the admission of steam, is shown, in its relation to the port *e*, at *M*, *N*, *O*, *P*, *Q*, *R*, and *S*, and the inner edge which controls the exhaust is shown at *M′*, *N′*, *O′*, *P′*, *Q′*, *R′*, and *S′*. It will be seen that at *N* the steam-port is wide open, and remains so until the valve gets into the position shown at *P*, when it begins to close the port. At *R* it is almost entirely closed. If now we draw a curve *M N O P Q R S* through the edge of the valve in its successive positions, that curve will show the movement of the valve in relation to the steam-port during the whole stroke. Horizontal lines 1 23′, 2 22′, 3 21′, etc., have been drawn between *f f′* and 4 20′ to represent each inch of the stroke, and the spaces between these lines has been subdivided by other lines which represent eighths of an inch, and the whole distance from *C* to *E* has been subdivided in the same way. The relation of the curve *M N O–S* to these horizontal lines will show exactly the position of the outer or steam admission edge *M* of the valve at all points of the stroke of the piston. Thus the distance of the curve on the line 1 23′ from the outer edge of the port *e*, as indicated by the dotted line at *w*, shows how wide the port was open when the piston had moved 1 in. of its stroke. A similar dotted line at *x* shows the width of opening at 14 in. of the stroke, and the intersection of the curve with the outer edge of the port at 20 in. of the stroke shows that the port was then closed and the steam cut off.

A similar curve *M′ N′ O′ P′ Q′ R′ S′* shows the position of the inner or exhaust edge *M′* of the valve in relation to the port *e*. Other curves *S U M* and *S′ U′ M′* have also been drawn which represent the movement of the valve during the return stroke of the piston. The dotted line below *R′* shows the width of the opening of the port *e* to the exhaust when the piston had moved $20\frac{1}{2}$ in., and the intersection at *y* shows that the port was closed to the exhaust at $22\frac{7}{16}$ in. of the stroke.

The slight intersection of the curve *S U M* with the outer edge of the port *e* just below *M* shows that the port was slightly opened before the piston had reached the end of its stroke, and the intersection at *z* shows that the port *e* was opened to the exhaust when the piston still had to move 1 in. to complete its stroke.

It will thus be seen that such diagrams show very plainly the movement of a valve, and they present to the eye a diagram which shows its different positions during a whole revolution of the crank. A clearer idea may thus be formed of its action than it would be possible to have without some such a graphical representation.

QUESTION 119. *Can the drawing of such diagrams be simplified in any way?*

Answer. Yes; if it is observed that the only way in which the rocker effects the movement of the eccentric and valve is to reverse their motions in relation to each other. We may, for simplicity, suppose the rocker is removed and that the shaft and eccentric are located at *T″* above *T* and opposite to the valve, and that the eccentric is connected by a rod *m″ D*, directly with the valve. In that case, in order to move the valve in the same direction that it was moved with the rocker, it will be essential that the center *m″* of the eccentric be in the opposite position in its path from that in which it is shown at *m* below. This will be plain if the reader will follow the motions indicated by the darts at *m Y X* and *H*, and then observe the direction that *m″* and *H* are supposed to be moving. It should be observed that the center *m″* must be on the right side of the center line *T″ T* instead of the left, and that the distance *m‴ m″* from the center line must be the same as *m m′* equal to *j k* or $1\frac{1}{16}$ in.

On the middle of *C E*, the vertical center line of the valve-face, we will now take *A* as a center, and draw a circle *m″″ n″–s″* to represent the path of the center of the crank-pin. It will also be imagined that the center *T* of the shaft is located at *A*, and that the circle *m″″ n″–s″* represents the path of the center of the eccentric, and that its center *m″″* occupies the same relation to the center line *C E* that *m″* does to *T″ T*—that is, it is $1\frac{1}{16}$ in. to the right of *C E*. If now we draw a vertical line through the center *m″″* of the eccentric upward it will coincide with *i h*, the center line of the valve. By drawing a line *A u* through the center *m″″* of the eccentric to the circumference of the large circle, which represents the path of the center of the crank-pin, and then from *u* the intersection of this line with the large circle, laying off a space *u v* equal to 45 degrees, and draw a line *v A*, the intersection of this line at *n″* with the path of the center of the eccentric will give the position of its center when the piston has moved 4 in. The successive positions *o″ p″ q″*, etc., of the curve of the eccentric can then be laid out in the way described, and by drawing perpendicular lines through these centers they will give the corresponding positions of the centers of the valve.

QUESTION 120. *What is the effect of increasing the lap of a valve if the travel remains the same?*

Answer. It shortens the period for the admission of steam—that is, it cuts the steam off earlier in the stroke. It also closes and opens the ports to the exhaust earlier. Thus in fig. 70 motion curves have been drawn for a valve with $1\frac{1}{4}$ in. lap and $4\frac{1}{2}$ in travel. From the steam curve *M N–S* it will be seen that the steam-port is closed at *q* or at $16\frac{1}{2}$ in. of the stroke instead of $20\frac{1}{2}$, as it is when the valve has $\frac{7}{8}$ in. lap, as shown in Plate II. The exhaust curve *M′ N′–S′* shows that the port *e* is closed on the exhaust side at $21\frac{1}{4}$ in. instead of $22\frac{3}{8}$ in., and that on the return stroke it opens the port to the exhaust at $21\frac{1}{8}$ in. instead of 23, as shown in Plate II.

It will also be seen that with the proportions of the valve and the travel represented in fig. 70, that the steam-port *e* is not opened wide at any period of the stroke.

QUESTION 121. *If the lap remains the same, what is the effect of reducing the travel?*

Answer. 1. Whenever the travel is less than twice the lap added to twice the width of one of the steam-ports, the latter will not be opened wide. This was shown in fig. 70, in which the valve has $1\frac{1}{4}$ in. lap and the steam-port is $1\frac{1}{4}$ wide, so that $1\frac{1}{4}+1\frac{1}{4}\times 2=5$ in. As the travel is only $4\frac{1}{2}$, the valve does not move far enough to uncover the steam-port completely. It is also shown in fig. 71 with a valve having $\frac{7}{8}$ in. lap and a travel of $3\frac{1}{2}$—represented by the motion curves drawn in full lines. It will be seen at *w′* that the greatest width of opening of the port is only $\frac{7}{8}$ in. The dotted curves show the motion of the valve with $2\frac{3}{4}$ in. travel. They show at *w* that the maximum opening of steam-port is only $\frac{1}{2}$ in.

2. The period of admission is reduced or the steam is cut off shorter. At *q* and *q′* in fig. 71 the motion curves show that the valve closes the steam-port at $13\frac{1}{4}$ and $17\frac{1}{4}$ in. of the stroke instead of $20\frac{1}{2}$ in. with $4\frac{1}{2}$ in. travel, as shown in Plate II.

3. The steam-port is closed and opened to the exhaust earlier. Thus at *y* and *y′* the curves show that the steam-port *e* is closed at $19\frac{3}{8}$ and $21\frac{1}{2}$ in. of the stroke instead of $22\frac{1}{2}$, as shown in Plate II, with $4\frac{1}{2}$ in. travel. At *z* and *z′* the curves show that the port is opened on the exhaust side at $21\frac{5}{8}$ and $19\frac{3}{8}$ in. of the stroke instead of 23 in.

4. The valve opens the steam-port for the admission of steam earlier with a short travel than with a long one. This is indicated by the two curves just below *M*, fig. 71. The full line shows that the port is opened when the piston still has $\frac{3}{16}$ in. to move before completing its stroke. The dotted curve, which shows the movement of the valve with a shorter travel, indicates that the valve opens the port, while the piston still has $\frac{7}{16}$ in. to move before it reaches the end of its movement.

QUESTION 122. *What occurs when the valve closes communication between the steam and exhaust-ports before the piston has completed its stroke?*

Answer. The steam contained in the cylinder in front of the piston is compressed by it, and it thus acts as a cushion to resist the momentum of the moving parts, which must come to a state of rest at the end of the stroke.

QUESTION 123. *What occurs when the valve closes communication between the exhaust-port and the steam-port ahead of the piston?*

Answer. The steam which has not been exhausted from the cylinder is enclosed in it and is compressed by the advancing piston, and it thus acts like the pre-admission of steam before the piston has completed its stroke—that is, as a cushion to resist the momentum of the piston and bring it to a state of rest.

QUESTION 124. *Does this compression result in any loss of energy?*

Answer. No, because the power required to compress the confined steam is again given out by its expansion behind the piston on its return stroke. In fact, it results in a direct economy, because by the compression of the confined steam the clearance spaces and steam-ways are filled with steam of a high pressure. Without such compression it would be necessary to fill them with live steam when the steam-port is opened.

QUESTION 125. *What is the effect of inside lap?*

Answer. It delays the release or exhaust of steam and increases the compression. For this reason no inside lap is usually given to valves for engines which run at a high rate of speed, as with it the exhaust steam has not time enough to

escape freely. In fact, in some cases what is called *inside clearance* is given to valves—that is, the width of the exhaust cavity of the valve is made somewhat wider than the distance over the inner edges of the steam-ports, so that it does not entirely cover them when it is in the middle of the valve-face. The effect of inside clearance is just the reverse of that produced by inside lap—that is, it causes the release to occur earlier in the stroke and compression later.

CHAPTER VII.

RESOLUTION OF MOTION AND FORCES.

QUESTION 126. *When one object is moved by two forces acting simultaneously in different directions but not opposite to each other, what occurs?*

Answer. It moves in the shortest path between the point from which it starts to that which it would reach in a given time if acted upon by each of the forces separately.

QUESTION 127. *How can this be shown?*

Answer. This will be made apparent if it be supposed that a billiard ball or other object is rolled on the floor of an elevator, used for raising and lowering goods or passengers, while the elevator is ascending or descending. Thus let *A*, fig. 72, repre-

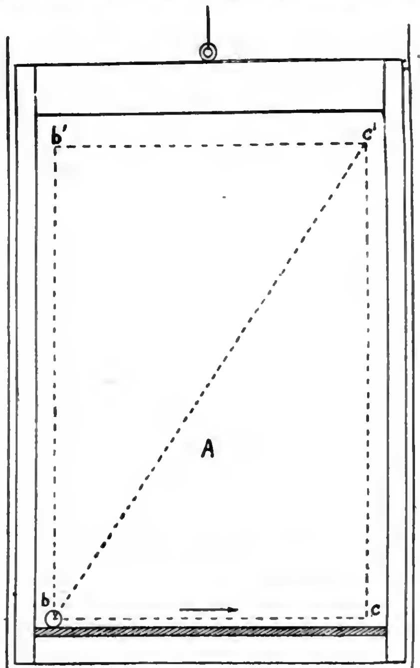


Fig. 72

sent a vertical section of the elevator, and *b* a billiard ball. If the distance from *b* to *c* is equal to 4 ft., and that from *c* to *c'* equal to 6 ft., then if the ball is rolled from *b* to *c* at the rate of 4 ft. per second while the elevator is standing still, the horizontal dotted line *b c* would represent its path. But if the ball is not rolled, and the elevator ascends at the rate of 6 ft. per

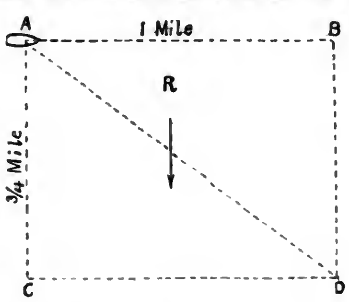


Fig. 73

second, then the vertical dotted line *b b'* would represent its path. If, however, the elevator is going up at the same time that the ball is rolling, then, while the latter is moving horizontally 4 ft., from *b* to *c*, it is also ascending 6 ft., so that its path would be represented by the diagonal line *b c'*.

The same principle is also illustrated if a boat is rowed across a river which flows at a rate of, say, three miles an hour. If the river is a mile wide, and the boat is rowed at a speed of four miles an hour, it will take a quarter of an hour to cross. But while the boat is being rowed across it also drifts three-quarters of a mile down-stream with the current, as illustrated in fig. 73, in which *R* is the river and *A* the starting point of the boat. If there was no current in the river and the boat was rowed in the direction *A B* at the speed mentioned, it would cross and reach *B* in a quarter of an hour. On the other hand, if it were allowed to drift with the current and were not rowed, it would float down stream three-quarters of a mile to *C* in the same time. If when the boat reached *C* there was then no current, and the boat was rowed across, it would reach *D* in 15 minutes after leaving *C*.

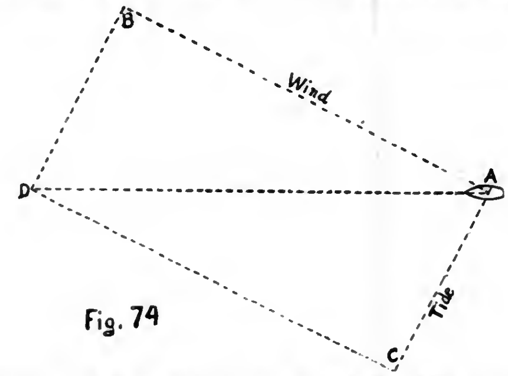


Fig. 74

If, however, the boat starts from *A* and is rowed in the direction *A B* while it is crossing, it will simultaneously drift downstream with the current, so that it will take the diagonal path *A D*, and will reach *D* in the same time that would be required to row from *A* to *B* or *C* to *D* if there was no current, or to float from *A* to *C* if the boat was not rowed.

QUESTION 128. *How can we determine graphically the direction and distance which an object like a boat will move if acted upon by two forces as described?*

Answer. If we will draw one line *A B*, whose direction and length represents to any convenient scale the direction and the

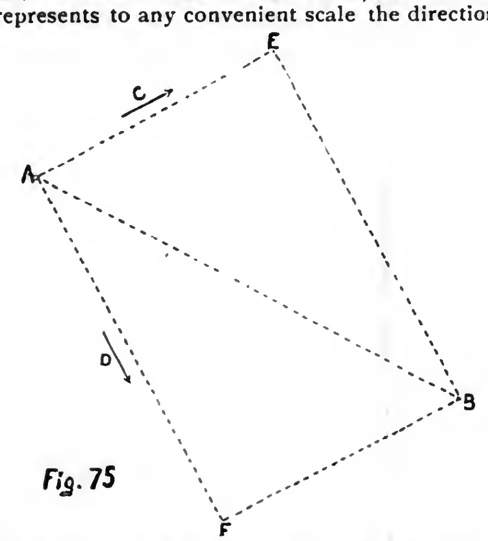


Fig. 75

distance that the body would be moved by one force in a given time, then draw another line, *B D*, representing in the same way the direction and distance that the object would be moved by the other force, and then draw a diagonal line from the starting point *A* to the terminal point *D*. Or we may proceed in the reverse order and draw *A C* first, and then make *C D* equal and parallel to *A B*, and then complete the diagram with the diagonal line *A D*. It should be noticed that *A B* must be equal and parallel to *C D*, and *A C* equal and parallel to *B D*, so that the line *A D* is a diagonal of a parallelogram whose sides are equal and parallel to the direction of the two forces which simultaneously act upon the body.

In fig. 72 the lines *b b'* and *c c'* are equal and parallel, and so are *b c* and *b' c'*, so that *b c'* is a diagonal of the parallelogram *b b' c' c*. Hence, we see that the motion which results from the action of two forces, or the "*resultant*," as it is called, is the diagonal of a parallelogram, the sides of which represent the extent and direction of the motion which would have been produced by each force acting separately.

QUESTION 129. *How is the general principle stated in scientific language?*

Answer. It is said by Rankine: "If two forces whose lines of action traverse one point be represented in direction and magnitude by the sides of a parallelogram, their *resultant* is represented by the diagonal."

QUESTION 130. *How can this be still further illustrated?*

Answer. Let it be supposed that a sail-boat *A*, fig. 74, is

acted upon by the wind so that in a given time, say a half hour, it would be moved in the direction and a distance represented by the line $A\ B$, and that in the same time the tide would carry it from A to C. Now, lay down $A\ B$ representing the effect of the wind, and $A\ C$ that of the tide, and draw $B\ D$ equal and parallel to $A\ C$, and $D\ C$ equal and parallel to $B\ A$, then the diagonal $A\ D$ will represent the direction and the distance the boat will move under the combined effect of wind and tide.

QUESTION 131. *What is the movement which results from the combined action of two or more forces, and which in figs. 73, 74, and 75 is represented by the diagonals of the parallelograms, named?*

Answer. It is named the "*resultant.*"

QUESTION 132. *What are the forces represented by the sides of the parallelogram, and which act upon a body to produce the resultant, called?*

Answer. They are called the "*components.*"

QUESTION 133. *If we have a resultant and wish to ascertain two components acting in given directions which would produce the resultant, how can we do it?*

Answer. This can be done by drawing a line representing the resultant in direction and length; then from its extremities lines must be drawn representing the direction of the components. A parallelogram will thus be constructed of which the resultant is the diagonal, and the sides will represent the components. Thus, suppose $A\ B$, fig. 75, represents the direction and the distance which a boat is carried by the combined action of the wind blowing in the direction $A\ E$, and of the tide flowing from A toward F; if we want to find out how far the wind or how far the tide would carry the boat in the time that it moves from A to B, we draw the line $A\ E$ through A in the direction of the wind, and $A\ F$ also through A in the direction of the tide. We then complete the parallelogram by drawing $B\ E$ through B and parallel to $A\ F$, and $F\ B$ parallel to $A\ E$. Then the side $A\ E$ represents the distance the tide would carry the boat, and $A\ F$ that which the wind would move it while it is going from A to B under their combined influence.

QUESTION 134. *What is the process by which two motions are resolved into one, or one into two, which has been described, called?*

Answer. It is called the "*composition of motion.*"

QUESTION 135. *Can the effect of two forces or strains acting simultaneously on a body be represented in the same way?*

Answer. Yes.

QUESTION 136. *How is a force or strain represented by a line?*

Answer. Forces are compared to or measured by the downward pressure which a 1-lb. weight exerts at the surface of the earth, so that it is easy to conceive that the magnitude of a pushing or pulling force may be described as equivalent to so many pounds. We may therefore take any length of line to represent one pound; that is, a line one inch long may repre-

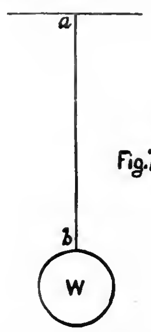


Fig. 76

sent a pound, one 2 in. would represent 2 lbs., and one 6 in. long 6 lbs., etc. Or we may take one-eighth of an inch to represent a pound, as in fig. 76, in which the weight W is supposed to be equal to 10 lbs., and the line $a\ b$ is made equal to ten-eighths, or $1\frac{1}{4}$ in., and thus represents the magnitude of the force or weight W. In the same way, if a horse was pulling on a rope and exerted a strain of 100 lbs., we may make 1 lb. $=\frac{1}{100}$ of an inch, so that a line $a\ b$, fig. 77, 1 in. long will represent the force or strain which the horse is exerting on the rope. Or, taking the illustration of the boat in fig. 73, it may be supposed that the person rowing it exerts a force of 24 lbs., while the current of the river is equal to 18 lbs. This diagram has been drawn so that one-sixteenth of an inch is equal to one pound. The line $A\ B$ is therefore $1\frac{1}{2}$ in. long, and $A\ C$ $1\frac{1}{8}$ in. long. If the parallelogram is completed the length of the diagonal $A\ D$ will then represent the resultant of the two forces, or their combined effect on the boat in the direction $A\ D$.

From what has been said, it will be seen that a line may be made to represent the magnitude of a force, and also the direction in which it is exerted. Thus, in fig. 76 the line $a\ b$ represents a force which is exerted downward; in fig. 77 the force represented by $a\ b$ is exerted horizontally, and in fig. 74 $A\ D$ acts diagonally. Therefore it is plain that the length and position of a line may be made to represent the magnitude and direction of a force.

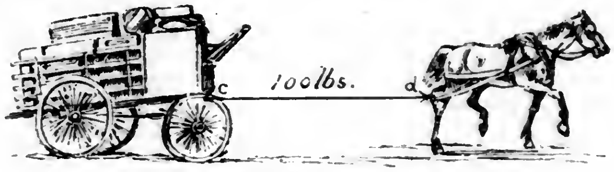


Fig. 77

QUESTION 137. *Does the principle of the composition of motion apply to forces or strains exerted by bodies at rest?*

Answer. Yes.

QUESTION 138. *How can we show this experimentally?*

Answer. If we will suspend a weight W, fig. 78, equal, say, to 10 lbs., by two inclined cords $b\ f$ and $b\ g$, which pass over pulleys f and g, it will be found that the weights A and B, which will balance W, can be determined as follows: As the force exerted

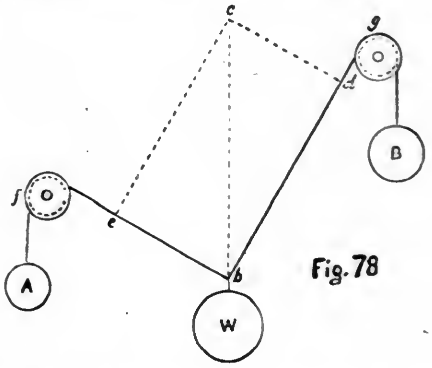


Fig. 78

by the weight W acts downward, its direction is represented by the perpendicular line $b\ c$. If now we lay off the distance $b\ c$ to any convenient scale, say $\frac{1}{8}$ in. = 1 lb., to represent the weight W, and then draw the lines $c\ d$ and $c\ e$ parallel to $f\ b$ and $g\ b$, then $c\ d$ or $e\ b$ will represent the strain on the cord $b\ f$ and $c\ e$,

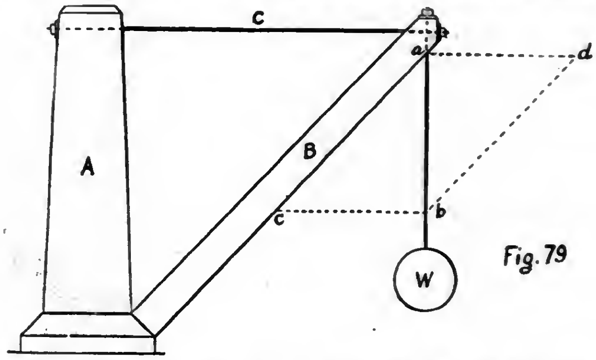


Fig. 79

or $d\ b$ will represent that on $b\ g$, and they will be equal to the weights A and B, which will balance W. Hence, we see again that the *resultant* of two forces is the diagonal of a parallelogram, the sides of which represent the direction and magnitude of those forces.

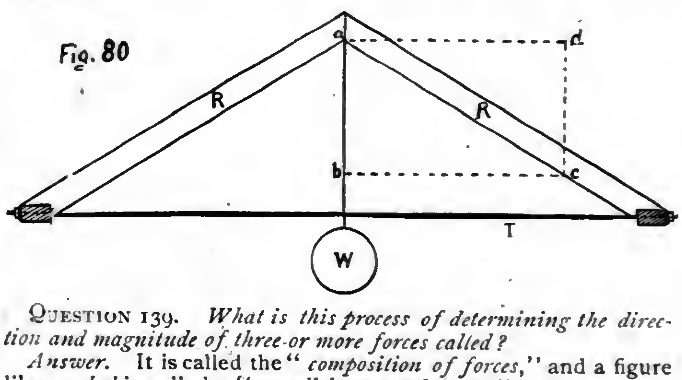


Fig. 80

QUESTION 139. *What is this process of determining the direction and magnitude of three or more forces called?*

Answer. It is called the "*composition of forces,*" and a figure like $c\ e\ b\ d$ is called a "*parallelogram of forces.*"

QUESTION 140. *What other illustrations may be given of the application of this principle?*

Answer. The strain on the parts of a common crane for lifting heavy objects can be deduced in this way. Thus, let A represent the post, B the jib, and c the tie rod of such a crane. If W equals 1,000 lbs., if we make $a\ b = 1{,}000$, and draw $b\ c$ parallel to C, then the length of the line $c\ b$ will represent the strain on the rod C and $c\ a$ that on the strut B. It will be plain from the figure and a little reflection that the effect of the weight W will be to compress B and pull C apart. Therefore B is said to be subjected to a *strain of compression* and C to one of *tension.* If the parallelogram of forces was completed the line $a\ d$ would be drawn parallel to C and to $c\ b$, and $b\ d$ parallel to B or $c\ a$. In most cases all that is needed to determine a strain on a structure is to draw a triangle like $a\ b\ c$, which is one-half of the parallelogram $a\ c\ b\ d$.

A roof or bridge truss like that shown in fig. 80 is another illustration of this principle. In this $R\ R$ are the timbers or rafters, and T a tie-rod, and W a weight resting on the rafters. If $a\ b$ is made equal to W, and $b\ c$ drawn parallel to T, then $a\ c$ will represent the strain on R and $b\ c$ that on T. If the inclination of the timbers $R\ R$ is the same, they will each be subjected to an equal strain, and the foot of the one will push against the tie-rod with a force just equal to that exerted by the other timber at the opposite end.

QUESTION 141. *Can the velocity in different directions of a moving body also be represented by a parallelogram?*

Answer. Yes, this is shown in fig. 72 in the case of the billiard ball and elevator. Here the ball b had a velocity of 4 ft. per second in the direction of the horizontal line $b\ c$, and a vertical velocity of 6 ft. per second, as shown by the line $b\ b'$. If it is moved simultaneously at these velocities and in the directions indicated by the lines, then, as was shown, it will move in a direction and a distance equal to the length of the line $b\ c'$ in the same period of time; $b\ c'$ therefore represents the velocity of the ball under the combined action of the horizontal and vertical velocities.

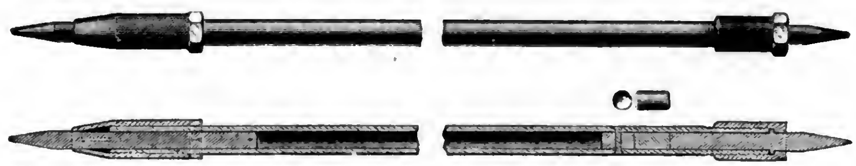
On the other hand, if we know the velocity at which the ball moves in the direction $b\ c'$, and wish to ascertain the speeds at which it moves horizontally and vertically, all we need do is to draw a parallelogram whose sides represent the direction of the velocity which we want to ascertain.*

(TO BE CONTINUED.)

Manufactures.

Improved Special Tools.

MESSRS. PEDRICK & AYER, of Philadelphia, have lately introduced a new adjustable shrinkage gauge for turning out locomotive tires and similar work. The novelty of it consists of the space pieces that are used in determining the size for shrinkage. There are two of them, the first about 1 in. in length; with this block in its place, the gauge is set to the diameter of wheel center; it is then removed and the second or allowance block is put in its place. This second block is made shorter than the first by a distance exactly equal to the amount of shrinkage which it is desired to allow in the tire. As they are ground up to micrometer caliper, one gauge answers for all different diameters and has shrinkage blocks conforming to the Master Mechanics' allowances, adopted in June, 1886. Should any other than the adopted standard be desired, extra blocks can be furnished. The accuracy of this gauge is not affected in the least by the wear on the points, as they are adjustable. This gauge is shown in the accompanying engraving.



The same firm has also lately introduced a portable machine for cutting key-seats in shafts, which will work in almost any position, either by hand or power. It can be used to cut a key-seat in an axle under a locomotive and in many similar places, where the work is usually very difficult.

* The principle of the resolution of motion, forces and velocities has a direct application to the action of the piston, connecting-rod and crank, which will be discussed in the next chapter.

Electric Street Cars.

CARS on the Van Depode system receiving their power through a traveler on an overhead conductor, are to be run on the street railroad between Brooklyn, N. Y., and Jamaica. The electric plant is now nearly completed.

The Richmond Union Passenger Railroad has nearly completed its line, and it will be in operation early in January. The power is taken from overhead wires. The cars are to be heated in winter by Burton's electric heater.

The West End Company in Boston is experimenting with a car fitted with a Weston motor, the power being derived from storage batteries on the Julien system.

Manufacturing Notes.

THE Tanner & Delaney Engine Company of Richmond, Va., has changed its name to the Richmond Locomotive & Machine Company. The plant has been considerably extended, and the company is prepared to build stationary engines, general machinery, and locomotives.

THE Ensign Car Works at Huntington, W. Va., are building for the Louisville & Nashville road 1,000 flat cars 34 ft. long and having a capacity of 60,000 lbs. each.

THE Canadian Locomotive & Engine Company at Kingston, Ont., has a contract for 14 locomotives for the Intercolonial Railway.

THE Baldwin Locomotive Works in Philadelphia are building 25 freight engines for the Philadelphia & Reading road.

THE East Chicago Steel Works at Hammond, Ind., are now in operation. The Bessemer steel plant consists of two 3-ton converters and a blooming mill, and its full capacity is 250 tons a day.

THE Manchester Locomotive Works at Manchester, N. H., are at work on a heavy order for the Atchison, Topeka & Santa Fé Railroad.

A CHARTER for a corporation to be known as the Oliver Iron & Steel Company of Pittsburgh has been granted. The corporators are Henry W. Oliver, Jr., David B. Oliver, James B. Oliver, John Phillips, and John Smith. The capital stock of the new company will be $1,500,000. It is a reorganization of the present company of Oliver Brothers & Phillips, with a limited liability.

THE Pittsburgh Tube Works have taken a contract to furnish 68 miles of wrought-iron pipe, to be used to carry water for irrigating purposes near Los Angeles, Cal. Most of the pipe will be 2 in. in diameter.

IRON-ORE shipments from the Lake Superior region this year have been 4,283,169 tons, an increase of 1,142,764 tons (36¼ per cent.) over 1886. Of this year's shipments, the Marquette District furnished 1,736,811 tons; the Menominee District, 1,116,832 tons; the Gogebic District, 1,040,727 tons; the Vermillion District, 388,799 tons.

THE Morgan Engineering Company at Alliance, O., has received the contract for the two large overhead traveling cranes for the gun-shop at the Washington Navy Yard. One of them is to be finished in 12, the other in 15 months. The leading dimensions are: One to have a span of 62 ft., at a height of about 40 ft. above floor line. This crane will have a capacity to lift guns weighing 125 tons, about 200 ft. travel lengthwise, and about 50 ft. crosswise of shops, and will be one of the largest cranes ever built in the world. The other crane is to have a span of about 52 ft., to have a lifting capacity of about 45 tons, to have a travel of about 480 ft. These cranes will cover workshops respectively of about 220×62 ft. and 480×52 ft., with a lift of about 40 ft. Each of the cranes is so designed as to have various speeds of hoist and travel in all directions to suit the varying weights of loads, from the lightest to the greatest or maximum loads, the lightest loads being handled in all directions rapidly, and the heaviest at speeds to suit the greatest activity such loads could be handled. Automatic stop-motions

are placed on the various motions that automatically prevent the travel of cranes in any direction beyond their maximum limits.

Marine Engineering.

THE Pusey & Jones Company in Wilmington, Del., recently launched the iron steamer *Manteo* for the Old Dominion Steamship Company. The principal dimensions are: 190 ft. long on the water-line, 26 ft. beam, 10 ft. 3 in. depth at side, moulded, and she is provided with a compound surface-condensing engine with cylinders 17 and 34 in. diameter, 28-in. stroke, and two Scotch boilers, 8 ft. diameter, 12 ft. long, built for a working pressure of 105 lbs. per square inch. The boat is designed for passengers and freight, and has 15 state-rooms.

CHARLES P. WILLARD & CO., of Chicago, have built a 70-ft. twin-screw passenger steamer for Oteri & Co., agents of the Pacific Mail Steamship Co., at Buenaventura, United States of Colombia. The steamer will be used for carrying passengers to Panama from Buenaventura.

THE Harlan & Hollingsworth Company in Wilmington, Del., is to build a new propeller to run between Wilmington and Philadelphia. The boat is to be 185 ft. long, 28 ft. beam, 40 ft. wide over the guards, and 10 ft. depth of hold. The engine will be of the triple-expansion type with surface condenser, with cylinders $18\frac{1}{2}$, 27, and 42 in. diameter, and 24-in stroke. There will be two steel boilers of the locomotive type 8 ft. diameter and 23 ft. long, which will carry 160 lbs. working pressure.

THE Western Transit Company of Chicago has contracted with the Detroit Dry Dock Company of Wyandotte, Mich., for an iron steamer of 2,700 tons capacity. She will be propelled by a triple-expansion engine, with cylinders 23, 36, and 62 in. diameter and 48-in. stroke.

THE surveying parties for the Nicaragua Canal will have with them 13 steel canoes, seven 18 ft. and six 20 ft. long. These canoes were designed by William Cowles and built by L. H. Raymond at Greenpoint, N. Y. The parties are also supplied with a 20-ft. surf-boat of steel.

IT is stated that the first iron steamer built in America was the *Bangor*, launched at Wilmington, Del., from the yard of Betts, Harlan & Hollingsworth, in 1845. The *Bangor* was a screw steamer of 250 tons measurement, schooner-rigged, and was built to run between Boston and Bangor.

THE Colombia Navigation Company has made a contract with Pittsburgh parties for a stern-wheel steamer with steel hull, to run on the Atrato River in Colombia, South America. The boat is to be 166 ft long, 32 ft. beam, and 6 ft. depth of hold, and is not to draw over 52 in. of water when loaded. This is an order which, it was thought recently, would go to English parties.

Proceedings of Societies.

American Society of Civil Engineers.

A REGULAR meeting was held at the Society's House in New York, December 8. A resolution was passed fixing the dues for the proposed new grades for students and associate members, which it was deemed necessary to do at this meeting in order to comply with the constitution. The resolution specifies that in the event of the adoption of the grades of associate member and student the dues for associate members shall be the same as now fixed for associate, and the dues for the student grade shall be $10 for resident and $6 for non-resident students.

The Secretary then read the closing discussion on William Metcalf's paper on Steel, Some of its Properties; its Use in Structures and in Heavy Guns, which was read by the author March 2, 1887. This was followed by a paper giving some experiments on the Protection of Piles from Limnoria and Teredo in San Francisco Bay, by Marsden Manson.

The following gentlemen were elected members: Tucker Carrington Eggleston, Richmond, Va.; Charles Edward Newham, Vincennes, Ind.; Henry Bowman Seaman, Philadelphia, Pa. Juniors: William Pierson Field, Newark, N J.; Robert Van Arsdale Norris, Wilkesbarre, Pa.

Engineers' Society of Western Pennsylvania.

AT the regular meeting in Pittsburgh, November 15, the discussion of Mr. Ramsay's paper (on the Effect of Temperature on Iron and Steel) was continued by Messrs. Buchanan, Roberts, Reese, Phillips, Brashear, Ferris and Munroe.

Mr. C. P. Buchanan then read a paper on Tests of Steel Beams, giving data of some tests made on steel for girder bridges in the hydraulic testing machine of the Keystone Bridge Company.

Engineers' Club of St. Louis.

THE Club met December 7, President Potter in the chair, 29 members and 3 visitors present. The Executive Committee recommended Reno De O. Johnson, Oscar W. Raeder, James C. Simpson, and Albert H. Zeller for election to membership. On being balloted for, all were elected.

The Committee on nominations of officers for the coming year reported: For President, M. L. Holman; Vice-President, J. A. Ockerson; Secretary, William H. Bryan; Treasurer, C. W. Melcher; Librarian, J. B. Johnson; directors, William B. Potter and F. E. Nipher. On vote the report was accepted.

The Secretary then read his report, which was accepted and ordered filed. The Treasurer read his report. It was accepted and referred to the Executive Committee. The Librarian made a verbal report. There had been no happenings out of the usual line in his department. He mentioned the excellent service the library was doing for students of engineering; also promised to prepare a list of the Club's literature for use of the members. He mentioned having picked up a copy of Volume I of the *Transactions* of the British Institute of Civil Engineers, which would be accessible to members of the Club.

Robert Moore, Chairman of Committee on relations with Mercantile Library, reported progress. No definite agreement had been reached as yet, but he felt confident the Club's wants would be fully provided for. President Potter then read the report of the Executive Committee, which showed the Club to be in a prosperous condition. An amendment to the by-laws was proposed, which the Club decided to vote upon at the next meeting in the usual way.

P. M. Bruner then read a short paper on the Action of Frost on Concrete Work. He explained the difficulties met with, and reported the results of a series of experiments he had made on Portland cement; also offered suggestions for counteracting the influence of low temperatures. He said the addition of salt would lower the freezing point one degree for 1 per cent. addition up to the point of saturation, and would also increase the tensile strength. The discussion proved very interesting, those participating being Robert Moore, J. A. Seddon, Wheeler, Professor Johnson, Ockerson, Macklind, Flad, Holman, and Caldwell. But few reliable data were to be had. Professor Johnson offered to make a series of tests. It was shown that the best work was secured between the temperatures of 45° and 70° Fah.

New England Railroad Club.

AT the regular monthly meeting in Boston, December 14, the topic for discussion was Continuous Brakes for Freight Trains.

Mr. Lauder, of the Old Colony, opened the debate, arguing strongly in favor of the Westinghouse brake, and Mr. Marden, of the Fitchburg road, took the same ground. Mr. Adams, of the Boston & Albany, thought the Westinghouse brake was a good thing, but suggested that the trouble is that roads receive cars from so many other roads, it will be many years before it will be possible to run freight trains with the Westinghouse brake. Mr. Marden replied that a beginning should be made, and that if the Westinghouse is to be put on all cars, the first one must be equipped.

Mr. Smith, of the Boston Forge Company, asked what is the average age of freight cars, and it was stated that the average life of a freight car is from 11 to 15 years, and Mr. Smith suggested that that fact would indicate about how long it would take for equipping all cars with continuous brakes, providing every new car was equipped when built.

Mr. Turner, of the Turner-Beard Automatic Brake Company, referred to the recent exhibition on the Boston & Albany as showing that his brake has considerable power.

It was voted that the officers of the Club be instructed to prepare a circular, to be submitted to the various railroads of New England, asking them to appoint a representative to meet in national convention for the purpose of selecting a standard coupling for steam connections between passenger cars, such convention to meet at the call of the Committee appointed at the November meeting in New York.

The subject of heating cars with steam from the locomotive was taken up and discussed a short time, the special point considered being the ability to heat 10 or 12 cars with the thermometer below zero.

Engineers' Club of Philadelphia.

A REGULAR meeting was held at the House of the Club in Philadelphia, November 19, President T. M. Cleemann in the chair; 35 members and 1 visitor present.

The Secretary presented, for Mr. W. H. Nauman, a paper upon the Calorimetric Investigation of the Performance of a Compound Engine, embodying considerable tabular data.

Mr. J. E. Codman presented a description, illustrated by specimens, etc., of Cement Tests, showing the effect the shapes of specimens had upon the results.

There was some discussion by Mr. A. Marichal.

The Secretary presented, for Mr. C. H. Haswell, a specimen of Cement.

The discussion of Mr. C. G. Darrach's paper upon Boiler Specifications was continued by Messrs. J. T. Boyd, O. C. Wolf, P. Roberts, Jr., A. Marichal, and the Secretary. The Secretary presented a communication thereon from Mr. G. R. Henderson.

A REGULAR meeting was held in Philadelphia, December 3, at which nominations were made for officers to be voted for at the annual meeting.

Mr. Percy T. Osborne presented an illustrated paper on the Palmetto Railroad, the connecting link in a new through line to the South.

Mr. R. B. Osborne presented an illustrated paper upon the Unaccountable Deficiency in the Track of American Railways. Mr. Osborne deprecated the continued use of the unsatisfactory spike; offered a suggestion for a spike-headed bolt--partly in accordance with established English practice and partly of his own design—to pass entirely through the tie; stated that this design was in no way patented; and particularly requested full discussion of the subject by the members of the Club.

Considerable informal discussion followed.

The Secretary presented to the Library, on behalf of Messrs. R. B. & P. T. Osborne, Active Members of the Club, a handsome copy of Williams's copper-plate mounted Map of the United States, Canada, Mexico, Central America, West Indies, etc., which was received with a vote of thanks.

Engineers' Club of Kansas City.

A REGULAR meeting of this Club was held December 5. The Secretary read, in the absence of the author, a paper entitled Deviation of the Ship's Compass, written for the Club by Mr. H. C. Pearsons, of Ferrysburg, Mich.

After a brief discussion it was moved by Mr. Mason that a vote of thanks be extended to Mr. Pearsons for his valuable paper, and to Mr. Kiersted for the paper presented at the previous meeting. The motion was carried.

Mr. J. A. L. Waddell then read some abstracts from a paper on General Specifications for Highway Bridges of Iron and Steel, describing at length the letting of county bridges with some defects of methods in use.

Notice was given by the President that the annual meeting would be held December 19.

Civil Engineers' Society of St. Paul.

AT the October meeting of this Society in St. Paul, Vice-President Wood occupying the chair, the report of the Committee upon the entertainment of the American Water Works Association, at its meeting in St. Paul in July, was read and accepted. A vote of thanks was passed and also resolutions thanking the Engineers' Club of Minnesota for their kindness and courtesy in the reception and entertainment given by them to the members of this Club on the evening of September 15 at Minneapolis.

The paper of the evening was read by Mr. A. Munster upon the Calculation of Plate Girders. Mr. Munster discussed the formulæ in common use, showing their absolute errors, which vary to a large extent, and seriously impair the value of the results obtained by their use, as the errors amount not seldom to from 6 to 12 per cent., and frequently even more. Two original formulæ were proposed by Mr. Munster, which are at the same time much nearer accuracy and also easier of application.

This paper was discussed by the members present.

Master Car-Builders' Association.

THE Sub-committee appointed by the Executive Committee of the Master Car-Builders' Association to examine and report what couplers come within the limits established for the M. C. B. standard type, met in Washington, December 13. There were present E. B. Wall, Chairman; R. D. Wade, John S. Lentz, Godfrey W. Rhodes, John W. Cloud; M. N. Forney, Secretary. Representatives of a number of couplers were also present.

A special committee, consisting of Messrs. Wall, Cloud, and Forney, was appointed to adopt standard lines showing the form and the length of couplers, and was instructed to report to the Sub-committee.

The Sub-committee has made such arrangements with the representatives of the owners of the Janney patents in regard to the use of the lines of that coupler as will secure a satisfactory understanding with the railroad companies, through the Sub-committee, for the use of those lines should the Committee see fit to adopt them; such arrangements to be fully consummated before the Sub-committee makes its report to the Executive Committee.

Railroad Spring Manufacturers' Association.

A MEETING was held in Pittsburgh, November 29, at which all the makers of car-springs were represented. An Association with the above title was formed, and the following officers were chosen: President, Benjamin F. Atha, Newark, N. J.; Vice-President, Joel Farist, Bridgeport, Conn.; Secretary, Edward Guibert, New York; Executive Committee, Charles Scott, Philadelphia; Aaron French, Pittsburgh, and A. Delano, Detroit, Mich. Another meeting will be held early in January in New York.

American Society of Mechanical Engineers.

THE eighth annual meeting began in Philadelphia, November 28, with an evening session at the Continental Hotel.

President George H. Babcock delivered the annual address. He laid great stress upon the importance of mechanical engineering, and said that "the profession of the mechanical engineer underlies all forms of engineering, as well as architecture, manufactures, and commerce, while science is even dependent upon it for her means of progress." He said that it was the mission of the mechanical engineer to subjugate all natural forces and elements.

John E. Sweet read a paper entitled A New Principle in Steam Piston Packing. A discussion followed, in which Professors Webb and Wood, of Stevens Institute; G S. Strong, of New York; F. H. Ball, of Erie; Oberlin Smith, of Bridgeton; H. D. Parsons, of New York; A. Sinclair, of Chicago; O. C. Woolson, of Newark; Daniel Ashworth, of Pittsburgh, and F. R. Almond, of Brooklyn, participated.

On the second day, at the morning session, the report of the Council showed the number of members to be 813. Treasurer Wiley reported that the receipts during the past year amounted to $10,586, and the expenses to $10,413.

An election for officers to serve during the ensuing year resulted as follows: President, Horace See, Philadelphia; Vice-Presidents, W. S. G. Baker, Baltimore; Henry G. Morris, Philadelphia, and C. J. H. Woodbury, Boston; Treasurer, William H. Wiley, New York; Managers, Stephen W. Baldwin, New York; Frederic Grinnell, Providence, R. I., and Morris Sellers, Chicago.

The following papers were read: Experiments and Experiences with Blowers, and Economical Method of Heating and Ventilating an Office and Warehouse Buildings, by Henry I. Snell; Internal Friction of Non-Condensing Engines, by Professor R. H. Thurston, and Power-Press Problems, by Oberlin Smith.

In the afternoon the members visited the Baldwin Locomotive Works; Bement, Miles & Company's machine works; Bergner & Engel's brewery; William Cramp & Sons' ship-building works; Henry Disston & Sons' saw-works at Tacony, and other manufacturing establishments.

At the evening session the following papers were read: The Milling Machine as a Substitute for the Planer in Machine Construction, by John J. Grant. Frank Van Vleck being absent, his paper on Standard Section Lining was read by Professor R. H. Thurston, and a second paper on the same subject was read by Professor Hutton. Considerable discussion followed, during which Messrs. John J. Grant, Henry R. Towne, Orosco Woolson, T. Halsey, F. G. Coggin, and James B. Ladd participated. The next paper read, by Percy A. Sanguinetti, was

entitled Divergencies in Flange Diameters of Pumps, Valves, etc., of Different Makers. It was discussed by Henry R. Towne, W. Barnett Le Van, J. M. Witnan, A. H. Raynal, William Kent, William F. Mattes, and others. William O. Webber's paper, Centrifugal Pumps and their Efficiencies, was read by Professor Hutton, and was discussed by Professor Wood, Hugo Bilgram, and James E. Denton.

A committee, consisting of Percy A. Sanguinetti, E. F. C. Davis, William F. Mattes, S. S. Webber, and A. H. Raynal was appointed to consider the advisability of adopting standard sizes of flange diameters.

On the third day, November 30, the first paper presented, on Friction in Toothed Gearing, was read by Gaetano Lanza, of Boston.

The second paper read was by Jerome Soudericker, of Boston, on an Investigation as to How to Test the Strength of Cements.

Edgar C. Felton, of Steelton, Pa., next read a paper entitled, Notes on Results Obtained from Steel Tested Shortly after Rolling.

Lewis F. Lyne, of Jersey City, read a paper on the Use of Kerosene Oil in Steam Boilers.

A paper on the Improvement of Shaft Governors was read by Frank F. Ball. A paper on a Road-bed for Bridge Structures was read by O. C. Woodson. John Coffin read a paper on Steel Car Axles.

James M. Dodge, of Philadelphia, suggested a New Method of Stocking and Reloading Coal, in which he recommended the use of the flying extension. In this connection he said:

"The average cost of stocking coal on either side of a trestle to a distance of, say, 20 ft. is about 30 cents a ton, whereas the cost of stocking coal with the flying extension is but a fraction of this amount. There are four of these conveyors now in use at the wharves of the Philadelphia & Reading Railroad at Port Richmond, Philadelphia, and others in process of erection. By means of the flying extension and reloading conveyors it is possible to store immense quantities of coal on vacant land at some distance from the sea-coast and cheaply reload it and deliver it at tidewater as called for, instead of storing coal under expensive trestlework and upon valuable dock property."

In the evening there was a reception at the Academy of Fine Arts, given by citizens of Philadelphia.

The fourth day, December 1, was devoted to an excursion to Bethlehem, Pa. The members took a special train in the morning, and during the day visited Lehigh University, the Lehigh Zinc Works, and the Bethlehem Iron Company's mills. They returned to Philadelphia in the afternoon, and in the evening visited the Opera House, by special invitation.

The visit to Bethlehem concluded the meeting. It was decided to hold the spring meeting in Nashville, Tenn., but a resolution was afterward passed that the Society should meet in Cincinnati, O., and proceed to Nashville after one day's session in the other city.

Military Service Institute.

A REGULAR meeting was held on Governor's Island, N. Y., November 26. The paper for the meeting was by Captain Rogers Birnie, Jr., of the Ordnance Corps, and the subject was Gun-Making in the United States. The paper was exhaustive, and was prepared for publication rather than presentation to an audience. Consequently it was not read through, but summarized in places. It historically reviewed gun-making in this country, beginning with the Rodman and Dahlgren patents, which, some decades ago, gave this country a brief period of superiority in an industry in which she is now somewhat behind. He analyzed at length the cast-iron gun, showing its impracticability from every possible point of view, and said that it was practically abandoned in 1871. In view of the annual attempts to obtain appropriations for cast-iron guns, this analysis of them will be of public interest to all having sufficient technical information to grasp it.

He analyzed the various patents tested of late years, including the Lyman multicharge gun, the Woodbridge wire gun, the Norman-Wiard guns. He said that the only valuable results had been obtained from the conversion of the old smooth-bore Rodmans into 8-in. rifles, of which 210 had been completed and mounted. He further said that the lesson of the last 10 years in the Ordnance Department investigations showed clearly that success in gun-making would come from steady and persistent endeavors to perfect the best system, instead of endeavoring to find new systems. The multicharge gun was clearly inferior, under all possible circumstances, to the breech charged gun.

At great length, but at no greater length than the importance of the question, in view of the endeavors to get appropriations for cast-steel guns, he showed that the same fundamental objections which lie against cast-iron guns lie against those of cast-steel. The effect of cooling a cast-steel gun from the inside was nullified by the annealing of the gun afterward. He concluded that the only guns worth while to manufacture at the present time were built-up guns of forged steel. He also showed the meagerness of Congressional appropriations, stating that in 20 years only $1,500,000 had been expended for the obtaining of cannon, a sum no greater than was needed to complete a single steel cruiser without its armament.

AT a regular meeting held December 8, Lieutenant E. M. Weaver, Jr., read a paper on the Armament of the Outside Line, in which he referred to the exposed condition of the coast. He took up the recommendations of the Fortification Board, and argued that the kind of guns proposed along the coast would not ward off an enemy with a 10-mile range, but, on the contrary, would be an incentive to attack in order to turn the guns inland, against the property they were designed to protect. As no serious attack would be made by an enemy east of Penobscot Bay, efficient fortifications, with guns of at least 20-in. caliber, should begin at that point. Otherwise, and as proposed by the Fortification Board, a force landing at the bay could proceed, under cover of a fleet, as far as Portland, without much trouble. Thus adequate defenses along the Maine coast have more than a local bearing. There should be large guns also at Dover. Cape Ann offered few temptations to an invader, but Boston, although well entrenched by nature, needs larger guns than have been recommended. In regard to the next and most important point of defense, Narragansett Bay, the speaker had a good deal to say. It might be possible to protect the bay itself with the proposed 16-in. guns, but better arrangements would need to be made to save Newport from bombardment. With Newport destroyed and the passage clear into the Sound, the Connecticut towns and cities would at once become endangered, and a way would be opened toward New York. There ought, therefore, to be provisions at Narragansett Bay to repel invasion.

Points along Eastern Long Island and the Sound could then wait for fortifications until an emergency was actually threatened, but the protection for New York should at once begin on Hart's Island and at Hewlett's and Willet's Points on the Sound, and at Rockaway Inlet, East Bank, Sandy Hook, and Coney Island, with guns of at least 20-in. caliber at each point. Large guns might also be profitably put at Forts Lafayette and Wadsworth, but not at the expense of outside fortifications. New York could be safe only by keeping an enemy out of the Lower Bay. The property in danger at Portland, Boston, Newport and New York in case of war is estimated at $3,500,000,000. If one-tenth of 1 per cent. of that value were appropriated as an insurance of this property danger could be averted. The writer discussed the best way of making such guns. He concluded that the Government ought to supplement its own operations with private enterprise, and leave the decision upon results to the artillery instead of to theorists. The men best qualified to judge of guns were those who had to stand behind them. Gun-making had advanced in this country in spite of Government officials rather than through them, and hence private enterprise ought to be given a fair chance.

OBITUARY.

LOUIS A. BOSDEVEX, who died at his residence in Jersey City, N. J., December 3, had been for many years in the service of the Pennsylvania Railroad. For some years past he had been Master Mechanic in charge of the Meadows shops on the New York Division of that road.

ROBERT CURTIS, who died in Columbus, O., December 4, was born in Syracuse, N. Y., in 1835, and when still young entered the Erie Railroad shops in Buffalo. He afterward went to Milwaukee and was for several years on the Milwaukee & St. Paul road, and was then made Superintendent of the Bay State Iron Works in Milwaukee. In 1860 he was appointed General Foreman of the Columbus, Chicago & Indiana Central shops at Columbus, O., and soon after became Master Mechanic. He has since remained in the same position through all the changes in name and ownership of the road. He superintended the design and construction of the extensive shops lately completed at Columbus. Mr. Curtis stood very high in his profession, and in the Master Mechanics' Association his opinions and views on matters pertaining to mechanics were respected and known to be very valuable.

GENERAL ZENAS C. PRIEST, who died at Little Falls, N. Y., December 4, in the 82d year of his age, was almost if not quite the oldest railroad officer in this country, both in age and term of service. He was born in Herkimer County, N. Y., in 1806, and after working in turn as a blacksmith, a salesman, and cap-

tain of a packet boat on the Erie Canal, he entered the service of the old Utica & Schenectady Railroad in 1835, working first as a conductor and afterward as roadmaster. In 1840 he was made Superintendent of the Utica & Syracuse Railroad, and when the consolidation which formed the New York Central Company was completed, he remained with the new company as Division Superintendent. Notwithstanding his great age, General Priest continued actively at work until a few weeks before his death, giving up his duties only when his last illness disabled him. He was always considered an active and efficient officer. At the time of his death he had been 52 years in railroad work and 47 years a Superintendent. He was the only man who was in the employ of the Utica & Schenectady Company in 1836 who remained on the New York Central 50 years later.

Mr. James McC. Creighton, who died in Philadelphia, November 20, was born in Pittsburgh in 1833 and was educated in that city. During nearly all his active life he was engaged in various classes of transportation service. He became one of the assistants, at Pittsburgh, in 1852, of Leech & Co., who were then operating the portion of the Pennsylvania Canal east of the Allegheny Mountains. After holding positions in which he gained much experience in transportation affairs, he was, on January 1, 1865, appointed General Agent in charge of the Pennsylvania Railroad Company's interests at Pittsburgh. In 1874 he was appointed Superintendent of the West Pennsylvania Division. In 1879 he was appointed Manager of the Empire Line, and in 1880 General Freight Agent of the Pennsylvania Railroad. After holding this position for a few years he engaged in other business, and subsequently he was elected President of the Schuylkill River East Side Railroad. He resigned that office in 1885, to become President of the Ohio Valley Natural Gas Company, which position he held at the time of his death. Mr. Creighton was endowed with great capacity for the transaction of many of the intricate duties connected with the management of railroad affairs, and at various stages of his career rendered exceptionally important and useful service. A widow and three children survive him.

General William Hensley Emory, who died in Washington, December 1, was born at Poplar Grove, Md., and graduated from West Point in 1831, receiving a commission in the Second Artillery, but resigned two years later. After devoting himself to civil engineering the two ensuing years, he was reappointed First Lieutenant of Topographical Engineers. He was diligently engaged until the breaking out of the Mexican War in surveys on coast fortifications and in running the boundary between the United States and the British Provinces. He was Acting Assistant Adjutant-General of Kearny's expedition to California. He was brevetted Captain for his services on the Pacific Coast. He was promoted Lieutenant-Colonel for his services in running the boundary line between the United States and Mexico. His notes on the military reconnoissance of the Arkansas and Gila Rivers and New Mexico and California, ably written and highly interesting, show that he possessed no ordinary talent as a surveyor and scholar.

As a topographical engineer, Brigadier-General Emory had few equals. In 1855 he was appointed Major of the Second Cavalry and transferred to the First Cavalry, and until the breaking out of the Rebellion was employed in frontier duty. In 1861 he was appointed to a volunteer command, and served through the war as Brigadier and Major-General. He retired from active service in 1876, and has since lived in Washington.

James Carson Brevoort died December 7 at his residence in Brooklyn, N. Y. Born in New York City in 1818, he graduated from the École Centrale des Arts et Manufactures, in Paris, as a civil engineer, and before returning to this country made a tour of the manufacturing districts of England and studied carefully that country's system of railroad construction. During 1838 he was engaged at the West Point foundry, and in 1841 assisted as surveyor on the North-western boundary survey. The year following he accompanied Washington Irving, United States Minister to Spain, as private secretary and attaché of legation. In 1845 he married a daughter of Judge Leffert Lefferts and settled in Brooklyn, where he has since resided. In 1847 he was a member of the Charter Commission, and later served on the Brooklyn Board of Education and as a member of the Constructing Board of Water Commissioners. He assisted in 1863 in the formation of the Long Island Historical Society, of which he was the first President, holding the office for 10 years. In the same year he was made a Regent of the University of New York and received the degree of Doctor of Laws from Williams College. Among the many literary and scientific societies of which he was a member were the American Association for the Advancement of Science, the New York Historical Society, the American Geographical Society, the Massachusetts and Pennsylvania Historical Societies, and the Academy of Natural Sciences.

Mr. Brevoort inherited from his father a library of 6,000 volumes, including many rare and valuable Americana, collected in Europe from 1810 to 1832. He added to the library, which at present contains some 10,000 volumes. He had also a very valuable collection of medals, coins, and manuscripts, from which some years ago he began to make systematic distributions among institutions of learning.

PERSONALS.

Mr. F. N. Finney has resigned his position as Managing Director of the Wisconsin Central Railroad, after long service with the company.

Mr. Walter G. Berg, formerly Assistant Engineer, is now Principal Assistant Engineer of the Lehigh Valley Railroad, and will have special charge of work at the eastern terminus.

Mr. W. R. Coats, of Kalamazoo, Mich., has charge of surveys and estimates for water-works at Hillsboro, Ill.

Mr. F. W. Pratt is now Chief Engineer of the Wisconsin Central Railroad and its associated lines.

Mr. T. G. Baylor, Civil Engineer, late of Atlanta, Ga., has removed to Charleston, W. Va., where he will remain for the present.

Mr. Alfred D. Ottewell is Engineer of the California Bridge Company, and has his office in San Francisco.

Mr. R. J. Duncan, late on the Missouri Pacific, has been appointed General Superintendent of the Fort Worth & Denver City Railroad.

Mr. R. Angst is Chief Engineer of the Duluth & Iron Range Railroad, with office at Two Harbors, Minn.

The partnership lately existing between George R. Waite, Martin Van Harlingen, and Henry Mactier, under the firm name of Waite, Van Harlingen & Mactier, was dissolved on the nineteenth day of November, 1887, by mutual consent. Two of the old firm have formed a co-partnership, under the firm name of Waite & Van Harlingen, for the purpose of carrying on business as engineers and contractors at 308 Walnut Street, Philadelphia.

Mr. F. P. Dimpfel, well known as the inventor of the Dimpfel boiler, which caused much controversy in the mechanical world, is now employed in introducing a preserver and germinator for cereals and seeds of all kinds.

Mr. Samuel Spencer, who succeeds Robert Garrett as President of the Baltimore & Ohio Railroad Company, has been in the service of that company for nearly 20 years, and Vice-President for four years past. He is thoroughly familiar with the company's system, and is credited with more progressive ideas than some of his predecessors.

Mr. George R. Hardy has resigned his position as Chief Engineer of the Lake Shore & Michigan Southern road. He went to that road from the Boston & Albany a year ago.

Mr. W. M. S. Dunn, formerly General Superintendent of the Chesapeake & Ohio road, has returned to that road as Consulting Engineer.

Mr. Thomas M. King has resigned his position as Second Vice-President of the Baltimore & Ohio Railroad Company.

Mr. Burr Bassell, of Los Angeles, Cal., has been appointed Chief Engineer of the Semi-Tropic Land & Water Company.

NOTES AND NEWS.

Blast Furnaces of the United States.—The condition of the blast furnaces, and their weekly productive capacity in tons, on December 1, as given by the *Iron Age*, was as follows:

	In Blast.		Out of Blast.	
Fuel.	No.	Capacity.	No.	Capacity.
Charcoal	70	11,718	105	8,908
Anthracite	122	39,437	76	18,054
Bituminous and coke	144	88,835	65	22,997
Total	336	139,990	246	49,959

The *Iron Age* says: "As will be observed from the figures given, there has been a decline in the capacity of the furnaces running on anthracite and coke pig. As yet, this falling off is

small, but since then additional furnaces have gone out of blast. Still, the make continues heavy, at the rate of 128,322 gross tons per week, not counting in the charcoal furnaces, which add 11,718 tons weekly, making the total 140,040 tons. The tendency, however, is now evidently in the direction of a slightly reduced make."

Baltimore & Ohio Employés' Relief Association.—The September sheet of this Association shows the payment of benefits to members as follows:

	Number.	Amount.
Accidental deaths	7	$10,000
Accidental injuries	276	4,028
Natural deaths	9	4,000
Natural injuries	598	8,401
Physicians' bills	180	1,321
Total	1,070	$27,750

From the organization of the Association up to September 30 there had been made by the Association total payments of $1,510,051 in benefits.

The Brussels International Exhibition.—The International Exhibition at Brussels, Belgium, for which the arrangements are substantially completed, will open on the first Saturday in May, 1888, and will remain open until November 3. Applications for space must be filed before January 15, 1888, and entries made before April 15; exhibits must be in place by April 25.

Messrs. Armstrong, Knauer & Co. have been appointed authorized agents of the Executive Committee for the United States. Applications will be received by them and information given on application to their office at No. 824 Broadway, New York City.

The Dubuque Bridge.—The new highway bridge just completed at Dubuque, Ia., is the only bridge over the Mississippi except the St. Louis Bridge, built without a draw. The new bridge is 70 ft. above the ordinary stage of water in the channel and 50 ft. above high water. It rests on seven piers, substructures of masonry founded on piles, having an iron superstructure with an 18-ft. roadway, on each side of which is a 5-ft. walk. There are four spans, each 205 ft. long, two of 248 ft. and one of 363 ft. On the east side of the river two spans, each 120 ft. long, form a viaduct over the tracks of the Illinois Central and the Chicago, Burlington & Northern railroads, which had to be crossed in making the approach to the bridge. The 363-ft. span extends over the channel of the river, and is a cantilever span, with its center 5 ft. higher than the ends. The entire length of the bridge is 2,800 ft. Of this length the main bridge comprises 1,760 ft., and the approach on the east side 1,040 ft. The location of this bridge is just 75 ft. south of the railroad bridge, the draw of which swings under the cantilever span of the highway bridge.

The contractors for the entire structure were H. E. Horton & Co., and the contract price was $125,000.

Tin Production of the World.—The production and consumption of tin for 10 years past are estimated as follows, in tons:

	Production.	Consumption.
1877	34,367	32,371
1878	35,849	34,918
1879	38,882	37,839
1880	38,321	39,533
1881	39,388	43,483
1882	39,771	42,045
1883	45,375	45,686
1884	43,851	45,735
1885	42,976	43,039
1886	44,687	46,520

Experts think that no considerable increase of production can be expected from the present sources of supply. It will be seen that the consumption now exceeds the production.

Utilization of Waste Products.—In a lecture recently delivered before the Philosophical Society of Sheffield, England, Mr. A. H. Allen said that it was not so long ago that blast-furnace gases were allowed to burn freely at the mouths of the furnaces, and the utilization of them for heating the boilers and blast is a distinct step in advance. With furnaces consuming coke this is all that can be done, but the successful utilization of the tar and ammonia condensable from furnaces consuming bituminous coal is a further step of great practical importance. We must not forget the enormous quantities of slag which form another secondary product of the reaction in the blast-furnace. It is calculated by good authorities that $1\frac{1}{4}$ tons of blast-furnace slag is produced for every ton of pig-iron obtained, which in England would mean an average yearly production of 8,000,000 tons of slag. The enormous quantity of this material produced has doubtless stood in the way of its utilization, and where there is a constant demand for it for road-making purposes at a fairly remunerative rate there is not much encouragement to go farther with it. At Middlesborough, however, it has been found of great service in the construction of the breakwater at the mouth of the Tees, for which purpose about 500,000 tons of slag are used annually. Again, slag-wool is now being manufactured at the rate of 15 to 20 tons per week. It is used as a non-conducting material for covering boilers, and so forth, and to put under flooring to deaden the sound. At the works of the Britain Glass Company, in Northamptonshire, blast-furnace slag is run in a molten state into a glass-furnace, heated by Siemens gas, and is then mixed with about its own weight of sand and alkali, and made into glass. The slag which results from the basic process contains a considerable quantity of phosphate of lime, and a number of ingenious processes have been devised for recovering this in a comparatively pure state. At the Northeastern Company's Works, Middlesborough, they are making from 800 to 1,000 tons per week of the slag, and have just erected a large mill for grinding this into powder. They have already shipped upward of 60,000 tons of the raw slag to Germany.

A Locomotive with "Polygonal" Drivers.—The Hinkley Locomotive Company in Boston has just completed a locomotive of the ordinary eight-wheel pattern, but with one pair of driving-wheels only, the place of the usual second pair being taken by a pair of trailing-wheels. The engine has 18 x 24 in. cylinders and the drivers are 67 in. diameter.

The Swinerton locomotive driving-wheel is the peculiar feature of this engine. It differs from the ordinary driving-wheel in that it has a series of plane facets of any length from 1 to 2 in. around its periphery or tread, and these facets are continuous and connected with each other by very obtuse angles. The inventor claims that by this arrangement the adhesion is greatly increased.

The engine is owned by the Swinerton Locomotive Driving-Wheel Company, and is to be tried for a time on the Boston & Lowell road.

Irrigation in Southern California.—The Semi-Tropic Land & Water Company, in Southern California, is expending some $300,000 on the survey and sub-division of a tract of 32,000 acres of land, and on the development, storage, and distribution of water for both town and irrigation purposes.

The Sierra Madre range of mountains furnishes the major portion of the water owned and controlled by this company; artesian wells will supply a portion of the lands.

The general plan for the development of water is to drive tunnels near the base of the mountain at the most favorable points presented by the small side cañons leading into the main cañon. The geological formation is most favorable on the north-west side of the main cañon. The rock is principally gray granite, presenting many fissures well suited to the storing up and gradual conveyance away of the rain-fall and the melted snows from higher altitudes.

Several tunnels are being made which have yielded surprisingly large volumes of water. In one instance a tunnel was started in solid granite bed-rock, where a superficial view of the situation would promise only discouragement and ultimate failure, and after going in about 150 ft. from the portal, the granite rim was broken through, and a stratum of sand and bowlders saturated with water was encountered, which yielded a large stream.

The water from the tunnels and side cañons will be conveyed in small pipes as laterals to a larger one, which latter will discharge near the mouth of the main cañon into a large box-flume. There is 700 ft. of this flume, made of 2-in. rough redwood, and imbedded in the side of the cañon, which conveys the water of the stream out of its natural channel to a point from which an open cement ditch about 10 miles in length will conduct the water to the distributing reservoir.

At the head of the flume, near the mouth of the cañon, and in the channel of the stream, two cribs will be anchored to bed-rock in such a manner as to present little or no obstruction to flood-water and drift material during the rainy season. A safer and better plan, but more expensive, would be to convey the water out of its channel by means of a tunnel.

The open ditch (now about half completed) is rock-walled and cemented its entire length, and is estimated to carry about 5,000 "miners' inches" of water, or 100 cubic ft., per second.

In addition to the distributing reservoir there will be a storage and service reservoir for town use, thus providing two separate and independent systems of water distribution—one for irrigation, the other for domestic use.

It is proposed to use partly cement concrete pipe (where there will be no water pressure or head) and partly sheet-iron pipe for the irrigation system. Strong cast-iron pipe, ample for fire pressure, is to be used for the domestic supply.

	Range.	Weight per Cu. Ft.	Specific Gravity.	Resistance to Indentation.	Elasticity.	Transverse Strength.
WHITE OAK. *Quercus alba, L.*	East of the Rocky Mountains.	46.35	0.7470 (4)	3388 (6)	97089 (2)	905 (4)
CHESTNUT OR ROCK-CHESTNUT OAK. *Quercus prinus, L.*	Northeastern and in Kentucky, Tennessee, and Alabama.	46.73	0.7499 (3)	3688 (5)	125473 (1)	1031 (2)
BASKET OR COW OAK. *Quercus Michauxii, Nutt.*	Southeastern.	50.10	0.8039 (2)	3725 (4)	96373 (3)	1118 (1)
BURR, MOSSY-CUP, OR OVER-CUP OAK. *Quercus macrocarpa, Michx.*	Northern U. S.	46.45	0.7453 (6)	3730 (3)	92929 (4)	982 (3)
POST OR IRON OAK. *Quercus obtusiloba, Michx.*	East of Rocky Mountains.	52.14	0.8367 (1)	4415 (1)	83257 (5)	872 (6)
CALIFORNIA WHITE OAK. *Quercus Garryana, Dougl.*	Pacific Coast.	46.45	0.7453 (5)	3846 (2)	81109 (6)	879 (5)

Naval Notes.—The Navy Department has asked for proposals for a submarine torpedo boat. Bids will be received until March 12 next. The proposals must be accompanied by drawings and description of the boat which the bidder proposes to build. Information as to the general requirements to be fulfilled can be obtained at the Navy Department.

The work now in progress at the naval gun shop in the Washington Navy Yard employs nearly 400 men. There are now under construction four 10-in. steel breech-loading rifled guns for the monitor *Miantonomoh*, and ten 6-in. steel breech-loading rifled guns for general service. There is also a large amount of work going on in the fitting up of tubes, hoops, etc., for other guns. In addition to the gun work there are in progress four turret mounts for the *Miantonomoh's* 10-in. guns, and four central-pivot carriages for 6-in. guns. In the foundry there are 1,000 cast-iron shells for 6-in. guns. Work on the secondary battery for the *Chicago* has been discontinued for the present, and will not be resumed until a further appropriation is made.

A recent test made at Newport between a steam launch of the old naval pattern and one of the new launches of the Herreshoff make resulted in a very decided victory for the latter. The two were connected by a heavy hawser, stern to stern, and started in opposite directions. The Herreshoff boat, however, managed to make considerable headway, dragging the other boat after her.

Car Heating.—The Connecticut River Railroad Company, which uses the Emerson system of steam heating, has provided a new system for heating the cars at the terminus at Springfield, Mass. It consists of a series of underground steam-pipes from the boiler-house, running to partially buried boxes, where heavy rubber hose can be connected with the steam-pipes of a car. The side tracks where the cars are cleaned after a trip and are dusted for the start are opposite the boiler-house, so that the system could be easily tried, but the pipes could be carried a greater distance with but little more pains. All that has to be done when it is desirable to heat a car or a string of cars is to lift the cover from one of the traps and connect it with the steam-piping under the car. The whole string of say a dozen or 15 cars can be heated as well as one. The connection can be made at the ends of any of the intervening cars. Any car can be shut off. There are about a dozen of the traps scattered up and down the yard so that it is an easy matter to make connections with the steam.

The joint committee of the several railroad clubs appointed to consider the question of couplings for steam-heating pipes has held two meetings, but has taken no decided action.

The Central Railroad Company of New Jersey has had one train on the Newark & Elizabeth Branch equipped with the Gold system of steam-heating for some time, and has recently ordered all the trains on that branch to be equipped in the same manner. It is expected that, if the results this winter are satisfactory, all the passenger trains on the road will be supplied with steam heat next winter.

Oak for Railroad Ties.—The Forestry Division of the United States Department of Agriculture has issued the following:

"In the use of oak for cross-ties, the specifications of most roads, especially those of the South, call for White Oak (*Quercus alba*), a timber which is sought for also by almost every industry employing oak, and which is therefore rapidly decreasing and approaching comparative exhaustion. Meanwhile, millions of feet of Tan-bark or Chestnut Oak (*Quercus prinus*) are rotting in the forests, after being stripped of their bark, because their value for cross-ties is not known or is underestimated in many regions.

"This lack of appreciation of the value of this wood causes not only waste of the wood itself, but waste of the bark also, as without ready demand for the wood, it does not pay to peel the larger limbs.

"From information furnished by Dr. Mohr, of Mobile, Ala., an expert in forestry statistics and agent of this department, it appears that from the line of the Louisville & Nashville Railroad, south of the Tennessee River, between 5,000 and 7,000 cords of bark are shipped annually, involving the felling in that district alone of from 10,000 to 13,000 trees which are consigned to useless destruction, while capable of yielding not less than 100,000 first-class railroad ties.

"As to the lasting quality of the timber of Chestnut Oak experiences are reported from Cullman, Ala., to the effect that posts of this oak outlast those made of White Oak, partly probably because the timber is peeled. One reliable report states that Tan-Bark Oak posts were found to be sound after 12 years, while those of White Oak in the same construction had to be replaced several years sooner. Reports from railroad companies, where this wood is used for ties, give their life as from 5 to 10 years, while the reports for White Oak give from 3 to 12 years. In the average, all the oaks which are known as white oaks, last between 7 and 8 years in the road-bed.

"That the oaks of this class may be used for railroad construction interchangeably, and do not offer any appreciable differences in the qualities most essential for a good railroad tie, the following table, compiled from the *Census Report*, may serve to show. The column of specific gravity will allow an estimate in regard to adhesion of spikes, while the column of indentation allows an estimate as to resistance to cutting of rail. The position as to quality, in comparison with the other kinds mentioned, is indicated by numbers in parenthesis.

"From these figures it would seem that, contrary to the accepted notion, the White Oak, *par excellence*, is inferior in all particulars to the Chestnut Oak, and in general not superior to any of the others."

Prizes for Small Motors for Electric Lighting.—The prizes offered by the English Society of Arts for small power motors applicable to electric lighting are to be awarded on the results of a trial which is to take place in May or June of this year, if a sufficient number of competitors present themselves. The motors which may be entered for the prizes are portable, semi-portable, and detached steam-engines, either condensing or non-condensing gas-engines working with lighting gas, water gas, or producer gas; hydro-carbon engines, using either liquid or vapor hydro-carbon; water motors; compressed-air and exhaustion motors. The maximum power at which they may be tested is 20 H.P., and no competition will be held unless 10 motors, at least, are entered. The points of merit considered of the greatest importance will be: *a.* Regularity of speed under varying loads. *b.* Regularity of speed during the various parts of one revolution, or one cycle of revolutions. *c.* Power of automatically varying speed to suit arc lights. *d.* Noiselessness. *e.* First cost. *f.* Cost of running. *g.* Cost of maintenance. Further information can be obtained from Mr. H. Trueman Wood, Secretary of the Society of Arts, Adelphi, London, England.

THE RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

PUBLISHED MONTHLY AT NO. 45 BROADWAY, NEW YORK.

M. N. FORNEY, ... Editor and Proprietor.
FREDERICK HOBART. . . . . Associate Editor.

Entered at the Post Office at New York City as Second-Class Mail Matter.

SUBSCRIPTION RATES.

Subscription, per annum, Postage prepaid..............$3 00
Subscription, per annum, Foreign Countries........... 3 50
Single copies.. 25

Remittances should be made by Express Money-Order, Draft, P. O. Money-Order or Registered Letter.

MR. J. HOWARD BARNARD, 7 Montgomery Avenue, San Francisco, Cal., is the authorized Western Agent for the JOURNAL.

MR. FREDERIC ALGAR, Nos. 11 and 12 Clements Lane, Lombard Street, London, E. C., England, is the authorized European Agent for the JOURNAL.

NEW YORK, FEBRUARY, 1888.

A CORRESPONDENT writes us that about 40 years ago a pamphlet was published by a Mr. Payne describing a plan for a bridge across the East River at New York, and called by the inventor the "Flying Suspension Bridge." If any of our readers are possessed of a copy of that pamphlet, they would confer a favor on the Editor of the RAILROAD AND ENGINEERING JOURNAL by loaning it to him for a short time. The utmost care will be taken of it while in his possession.

OUR Northern neighbors have a right to feel a little proud this year, when one of the leading American technical societies and one of the leading railroad associations go to them for presiding officers. This is a kind of reciprocity to which no one can object, especially as Canada has always supplied faithful and valuable members to both societies.

THE Council of the Iron & Steel Institute of Great Britain has decided to hold the next autumn meeting of the Institute in the United States. A number of the prominent members of the Institute have already signified their intention of being present. The arrangements for the meeting have not yet been completed, but it will probably be held in September, and the headquarters of the Institute will be in Pittsburgh. The Iron & Steel Institute is the largest and most important body of a similar kind in the world, and at its meetings papers are usually read by practical and scientific men of the highest standing. Some of the members have visited this country before and are to some extent familiar with its resources; to many of them, however, this will be the first visit, and doubtless they will take advantage of it to study the country as far as their time and opportunities will permit.

This first meeting of a prominent association of English engineers on this side of the water will be a notable occurrence, and it will doubtless be made the occasion of many exchanges of courtesies by American societies.

A NEW source of petroleum supply, which may in time affect American trade with India and other Asiatic countries, has been found in the little-known country of Beluchistan, where the borings which have been in progress at Khatan are said to give indications of a large and constant supply. The new wells are at present remote from all except the most primitive means of transportation; but those who are familiar with the country say that there are few or no difficulties in the way of a pipe-line from the wells to the terminus of the Indian frontier railroad line. Of course the development of these wells will require time, but their connection with the outer world may be hastened somewhat from the fact that a supply of oil for fuel will be of great benefit to the military railroad which is now slowly finding its way into Afghanistan from India. On this line the supply of fuel is a difficult question, and the bringing of petroleum from Khatan by pipe would not only reduce the cost of operating it, but also provide it with the commercial traffic which it now lacks.

The length of the pipe-line required would be, it is stated, only about 65 miles, through a country rough and uneven, but presenting no formidable obstacles. A considerable quantity of the oil has already been brought from Khatan in barrels, and it is now being tested as to quality.

ACCORDING to the latest reported utterances of M. de Lesseps, the completion of the Panama Canal, which he has promised for 1890, is not to be that of the sea-level canal for which the plans provided originally. The present plan, he says, is to pass the section of greatest excavation by a temporary high level canal, to which ships are to have access through a series of huge iron locks at either end. These locks are to be built by M. Eiffel, the engineer who has designed and is building the 1,000-ft. iron tower on the Exposition ground in Paris. The high-level canal is to be 120 or 150 ft. (the height is variously given) above the sea-level. After this is opened, we are told, the excavation will be continued at the Culebra until the tide-level is finally reached. In other words, M. de Lesseps proposes to follow railroad practice, and use a sort of marine switchback until his permanent line is completed.

Whether this is practicable is not altogether clear. Two objections are suggested, the first that it will be difficult to find a supply of water for the 150-ft. level, and the other that the practicability of the proposed system of iron locks is not by any means established. Even if both these points be conceded, it is not at all certain that the work can be completed in two years, or that the diversion of the Chagres River can be completed so as to secure the western end of the canal from accident.

In this connection it may be noted that the French Government has refused to give the Canal Company permission to issue another lottery loan. It is announced, however, that bonds are to be issued on another basis.

THE only bill so far presented in Congress for the direct increase of the Navy is one providing for the construction of three gunboats or despatch boats of about 900 tons displacement, to have a speed of 13 knots. These are to be used specially as training ships, and are to take the place of the old vessels heretofore used for that purpose. Those vessels are of old style and construction and, moreover, will not last much longer without expensive repairs. A

training ship ought to represent the latest practice, if it is to serve properly the purpose for which it is intended.

IN selecting the names of the new cruisers for the Navy, Secretary Whitney has followed the practice of his predecessors, and has chosen those of the larger cities of the country. The *Atlanta*, *Boston*, *Chicago*, *Charleston*, *Baltimore*, and *Newark* had already been named, and now it is announced that the two cruisers under contract, heretofore known only as Nos. 4 and 5, are to be named *Philadelphia* and *San Francisco*.

In naming the new gunboats, however, the Secretary has begun a new series, and the *Concord*, the *Bennington*, and the *Yorktown* will commemorate the battles of the Revolution. The smaller gunboat is to be called the *Petrel*, apparently to give the *Dolphin* an aerial companion.

THE Zalinski dynamite gun has attracted much attention abroad as well as in this country, and has been the subject of much discussion among foreign naval authorities. The first actual order from Europe, we believe, is one from the Italian Government, which is for a gun capable of throwing a projectile weighing 600 lbs. This is to be used for experimental purposes; if successful, a number of the guns will probably be ordered.

THE Nordenfelt submarine torpedo boat, some trials of which are described elsewhere, is one of the most formidable vessels for coast and harbor defense yet built. For attack on a fleet the Nordenfelt boat is, apparently, free from most of the defects of the ordinary torpedo boat, and it would be extremely difficult, if not impossible, for an antagonist to injure her, if properly handled, simply for the reason that she cannot be seen when submerged, and presents a very small mark even when above water. The boat is, in effect, a submarine projectile which can be handled, turned, and made to strike just where it is wanted.

A BILL providing for the establishment of a naval reserve, or a naval militia, to include both ships and men, has been introduced in Congress, and is now in committee. Its provisions are very much in the line of the recommendations heretofore made in this direction by the Secretary of the Navy and Admiral Porter. The bill is apparently so well prepared, and is of such importance, that we give its provisions, almost in full, on another page.

The bill has attracted much attention, and it is to be noted that, while fault is found here and there with some of its details, the general principle seems to meet with approval from those interested in shipping both on the ocean and on the lakes.

THE steel rail production of the United States last year was the largest on record, reaching a total of 2,050,000 gross tons or 2,296,000 net tons. Much of this was, of course, absorbed by the great mileage of new road built, but the demand was swelled by the orders for renewals on old roads, which were, as usual in a prosperous year, greater than for several years past. Prices, however, were not maintained throughout the year, being at the close of the year $6 per ton below the opening of the year, and $7 below the highest point. Prices began to decline about the middle of the year, but fell slowly until October, when there was a sharp decline. By that time, however, the orders for the year had been substantially all placed. The output varied but little, that of the second half of the year being only a few thousand tons below the first. All the mills ran throughout the year pretty well up to their capacity, and with them, as with many other branches of manufacturing, 1887 was an exceptionally prosperous year.

THE new year opens for the steel rail mills very differently from the last. Just at present nearly all the mills are shut down, with no immediate prospect of opening. This state of things, however, is not the result of an absence of demand for rails, but of a difference of opinion as to prices. The makers claim that present prices are too low to afford a reasonable profit, and want to increase them, but buyers naturally do not take the same view, and the large orders which are generally placed early in the year have been so far withheld. This has led to a sort of dead-lock for the time, but this situation cannot be expected to last very long. The demand for rails for new road is, apparently, to be somewhat less this year than last, but the requirements for renewals and new work must still be large enough to afford a fair amount of work.

THE discussion of the project for building a bridge over the Hudson River at New York City has called out one definite plan for such a structure, which was presented to the American Society of Civil Engineers at a recent meeting by one of its members.

The merits of Mr. Lindenthal's plan need not be discussed here. There is no doubt that a good plan for a bridge can be had, if it is to be built. The chief trouble will be to secure such an agreement among the railroads which would use the bridge as will make it easy to raise the money needed. To do this will be the hardest part of the work.

THE most stupendous plan yet suggested is by a French engineer, who proposes to cross the English Channel from Ambleteuse to Folkestone by a bridge. The Channel at that point is about 25 miles wide, the depth of water varying from 40 to 200 ft. The plan provides for masonry piers rising some 35 ft. above the water, which are to carry lofty steel towers, the latter supporting the superstructure. The bridge spans are to be from 1,500 to 2,000 ft. long.

French papers say that the plan has advanced so far that a company has been formed and negotiations opened with English and French contractors, whose engineers are now considering the practicability of the work. Nothing is said, however, about the political reasons which were urged to defeat the Channel tunnel project, and which would seem to be quite as strong against a bridge.

Even if the bridge plan is practicable, its enormous cost makes it very doubtful whether it will be really undertaken by a private corporation. The English Channel will probably continue to be crossed by ships alone for a good many years to come.

THE number of accidents on the New York City railroads is surprisingly small, when all the conditions are considered. The reports of the city companies for 1887 give a total of 42 killed and 204 injured, against 31 killed and 164 hurt in 1886. The summary at hand does not state how many of these were passengers; probably a large proportion of them were not. While the city rail-

road passenger is generally exempt from the dangers of collision or derailment to which the traveler is exposed on steam railroads, he incurs certain risks in getting on or off the cars ; there is also the danger to outsiders which always arises from the movement of vehicles in crowded thoroughfares. The returns, however, show that the street cars in New York run over fewer persons comparatively than other vehicles do.

GRADE crossings of highways and railroads receive considerable attention from the New York Railroad Commissioners in their last report. They call attention to the many serious accidents resulting from such crossings, and recommend legislation not only to prevent any increase in their number, but also to provide for its gradual decrease.

THE introduction of the block signal system on one division of the New York, New Haven & Hartford road is a notable advance made by a company which has always been exceedingly conservative, and slow to adopt improvements. The business of the road is so large that it is hard to see how such action could have been postponed much longer consistently with safety in operation. There are several roads which do a larger business, but few or none which have so many fast passenger trains and so great a passenger business.

It may be noted also that the New Haven road is to be added to the list of four-track roads, the first section of the new third and fourth tracks having recently been opened for business. In another year the four-track line will cover the most crowded portion of the line, and it is the intention to carry it over the whole of the road from New Rochelle Junction to New Haven.

IN England, as in this country, the railroad is to a very great extent superseding the canal as a means of transportation. Before railroads were built the country was supplied with a system of canals on which a large traffic was carried, but it appears that a number of these water-ways, including some which we would class among the more important, have begun to fall into a dilapidated condition. Recently special complaint has been made by English papers of the state of the Thames & Severn Canal, which, it appears, is so much out of repair that it is difficult for boats to get through it at all. The traffic of this canal has decreased in a few years from about 44,000 tons to less than 30,000 a year, and this falling off has so reduced the tolls that the income is entirely too small to keep the canal in order, while this dilapidation, of course, diminishes the income. It is also insinuated that this state of affairs is partly due to the influence of the railroad companies with which the canal competes as a carrier, and it is openly charged that the railroad influence has made the managers neglect their work.

While it is not probable that the canal, even if kept in the best of order, would take business away from the railroads, to a very large extent, the managers of the latter evidently appreciate its influence as a regulator of rates, and understand that the effect which its improvement would have upon their business would appear more in profits than in the total traffic. Our English friends are just waking up to this view of the question, and when they fully realize its importance, some practical steps may be taken for repairing and renewing the canals.

In France and Germany the importance of water-ways has always been recognized. In those countries inland navigation has been not only maintained but extended, even where the country is well supplied with railroads, the practice in this respect being widely different from the English.

THE English military railroad on the frontier of Afghanistan, which has been the occasion of much controversy both from a political and an engineering point of view, is to make a further advance of 15 miles. The importance of this section, however, is much greater than its length would indicate, for it includes the most difficult work on the entire line, and it is expected that from two to three years will be required to build it, owing to the length of tunneling needed. When this is finished some 70 miles of comparatively easy work will take the line to the Helmund River, within easy distance of Candahar.

The Russians, on the other hand, have their Central Asian line in such a position that it can be carried into Afghanistan by comparatively light work, and can reach Herat in less than a year, should it be necessary.

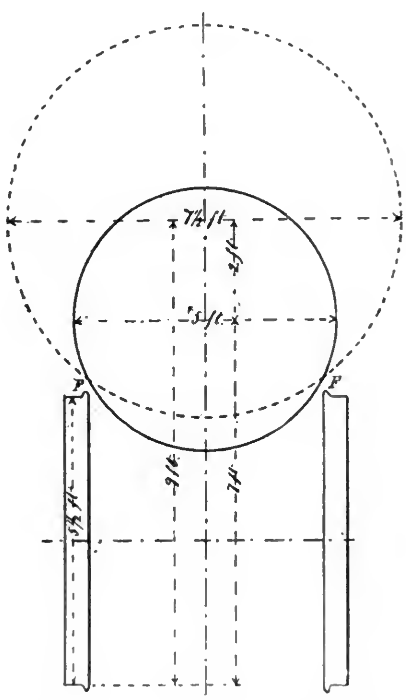
This contrast, and the advantage which the Russians would realize by it in case of war, is not a pleasant matter for the English, and the fault found with the Government is not diminished by the charge that its engineers had no adequate idea of the work to be done, or even of the best line to be taken, when the time arrived that the road was needed and ought to have been well on toward completion.

LOCOMOTIVES OF THE FUTURE.

A PARAGRAPH has recently been circulating in the daily press in which the public are informed that the largest passenger engine ever constructed is now being built in the Schenectady Locomotive Works for a Western road. The information given is not very definite, so that it is not possible to say whether it really is the largest passenger engine ever built ; but the fact that there are examples of passenger engines which weigh 100,000 lbs. or over leads to reflection and anticipation. "How big will locomotives be in 50 years from now ?" is a question that a mechanical engineer cannot help asking himself and his associates.

D. K. Clarke's "Recent Practice of the Locomotive" contains an engraving of a Mason locomotive, which was built about 30 years ago. It had 15×22-in. cylinders, $5\frac{1}{2}$-ft. wheels, and a grate $4\frac{1}{2}$ ft. long and 3 ft. $1\frac{3}{4}$ in. wide, giving a grate area of $14\frac{1}{4}$ square feet. This engine weighed about 55,000 or 56,000 lbs., and had about 800 square feet of heating surface. The Schenectady engine has a grate 8 ft.×3 ft. $6\frac{7}{8}$ in., which gives a grate area of $28\frac{1}{2}$ square feet. The heating surface is not given, but other passenger engines recently built have from 1,500 to 1,600 square feet, so that it may be said that within 30 years the size and weight of passenger engines has been nearly or quite doubled. Will this rate of increase continue, and in the year 1918 will there be passenger engines running which weigh 200,000 lbs. and over ? There can be no doubt that the discoveries which made steel rails and steel tires possible, and their general introduction and use, gave a great stimulus to the increase in weight of rolling stock. Besides this the weight of rails on main line road has recently been increased. With a rail weighing 56 lbs. per yard, the maximum load per wheel which was safe and

economical was about 10,000 lbs. With 72-lbs. steel rails, loads of 15,000 and 16,000 lbs. per wheel are not unusual. The speed of locomotives, however, has not been increased in the same proportion as their weight. Thirty years ago 50 and 60 miles per hour was not an uncommon maximum speed. Now 60 and 70 is about as high as we get on any of our lines. The weight of trains has probably grown as much as that of locomotives, and, perhaps, will continue to increase. Supposing, then, that the problem was presented to day of making a passenger locomotive of double the weight and capacity of the largest now in use. That would mean an engine of somewhat over 200,000 lbs. in weight, with a grate surface of 55 to 60 square feet, and a boiler with 3,000 square feet of heating surface, and cylinders 27 or 28 in. diameter. Boilers 5 ft. in diameter are now not uncommon ; 7½ ft. diameter would give about twice the sectional area. An eight-wheeled American engine, weighing 100,000 lbs., would have about 17,000 lbs. on each wheel. Double this weight, or 34,000 lbs. per wheel, would be enormous, and would require a very great increase in the weight of rails, and even then it would



be very doubtful if it could be carried without crushing both the tires and the rails. By distributing this load on six or eight wheels, the load per wheel would be 22,666 or 17,000 lbs., which is well within possible limits.

The experience of the last few years has shown that the height of the center of gravity is not a matter of so great importance as was formerly supposed. The first impression is that a high locomotive is as likely to upset as a high load of hay, and it takes a considerable time and some deductive reasoning to realize fully that the vertical inequalities and horizontal deviations from a straight line which a load of hay is expected to traverse bear somewhat the same relation to those of a railroad that high mountains do to the gentle undulations of prairie country, and therefore that an elevation of the center of gravity which would be disastrous to a load of hay may be quite safe for a locomotive on a railroad. Mr. Wootten had the courage of his convictions, and elevated the centers of the boilers of his locomotives 7 ft. 8 in. above the tops of the rails. The diagram herewith shows the height—7 ft.—which a boiler 5 ft. in diameter must be elevated above the rails, and the dotted line shows the position of a 7½ ft. boiler, with the same clearance of the flanges of the wheels at *F F*. It will be seen that the center of the large boiler must be 2 ft. higher than that of the small one, or 1 ft. 4 in. higher than Mr. Wootten's. When it is remembered, too, that the fire-box of Wootten's engine is on top of the frame and the cab on top of the boiler, it will be seen that if these and other parts were lowered the height of our hypothetical boiler may be quite practicable.

The experience with electric light engines during the past few years has indicated what may be done with high-speed engines, and in the light of that experience it may be that wheels of smaller diameters than 5½ ft. might be used, and the requisite speed be obtained by running the pistons at higher velocities than is the present practice with locomotives. This would permit the boilers to be lowered and the size of cylinders to be reduced, and, consequently, the reciprocating parts and wheels would all be smaller and lighter. This reduction in weight could then be put into the boiler, which is the source of all power.

It therefore seems quite probable that the size and capacity of locomotives will continue to increase, although it is likely that there will be some modifications of the present forms of construction which will permit of the use of larger fire-boxes, and of lowering those parts whose elevation with a changed construction will not be essential.

There are some sanguine people who also predict that the speed of locomotives will also be doubled in the shadowy future, into which none of us can see very far. Past experience has not shown an increase in speed corresponding with that of the weight and capacity of locomotives. The reason is not difficult to find. The capacity of a locomotive—that is, the load it can pull at a given speed—is proportionate to its weight ; that is, an engine twice as heavy will pull a train of double the weight. There is a physical law which unfortunately prevents the fulfillment of the predictions of the sanguine prophets of speed—that is, that the resistance of trains increases as the square of the velocity —probably at even a higher ratio at high velocities ; and what adds to the difficulty is that when the amount of work is thus increased it must be done in less time. Thus at 60 miles an hour the resistance is roughly twice as great as it is at 40 miles, and the work must be done in two-thirds of the time. This law stands in the way of an increase in speed beyond limits which are soon reached in practical service.

NEW YORK CITY PASSENGER TRAVEL.

THE management of the passenger movement of a large city is always a complex problem, the solution of which becomes continually more difficult as the growth of the city at once increases the number of people to be carried and the distances over which they have to pass. This is particularly the case in New York, where, on account of the shape of the city, the movement is nearly all in one direction and the distances are greater, and where the number of passengers is increased by the daily influx of a large suburban population. Probably there is no city in the world in which the number of persons using the public conveyances bears so large a proportion to the resident population.

The returns made to the Railroad Commission by the New York City railroad companies for the year ending September 30 last, when compared with those for the previous year, show some interesting facts.

The total number of passengers carried was as follows :

	1887.	1886.	Changes.
Elevated (steam) railroads......	158,963,232	115,109,591	Inc., 43,853,641
Surface (horse) railroads......	199,574,966	206,930,070	Dec., 7,355,104
Total.......	358,538,198	322,039,661	Inc., 36,498,537

A further examination of the figures may serve to explain, or, at least, to make clearer, some of the changes shown in this table.

The surface or horse railroad companies operating lines in the city are 18 in number. Ten of these operate lines running up-and-down town (as a New Yorker would say)—that is, in the direction of the main traffic ; five have lines which do a mixed business, partly up-and-down town and partly across the city, while the remaining three are entirely cross-town lines—that is, they are short lines serving as feeders for the main lines of travel, and carrying people between them and the ferries and other points on the river fronts. The elevated railroad traffic is all up-and-down town.

The passengers carried by the surface roads were divided among the three classes of those lines indicated above, as follows :

	1887.	1886.	Changes.
Up-and-down-town lines....	141,225,765	153,876,582	Dec., 12,650,817
Lines with mixed business......	50,968,161	47,908,575	Inc., 3,059,586
Cross-town lines	7,381,040	5,144,913	Inc., 2,236,127
Total.......	199,574,966	206,930,070	Dec., 7,355,104

This statement shows very plainly that the loss of travel by the surface roads has been wholly in those lines which come into competition with the elevated roads.

Unfortunately, the companies in their reports give only the total number of passengers carried, so that it is impossible to give exact figures for the total movement of passengers up and down-town. The cross-town movement can only be reached approximately. If this be done, and that movement dropped entirely, the following table will give nearly the total travel of passengers on the main lines :

	1887.	1886.	Changes.
Elevated roads ..	158,963,232	115,109,591	Inc., 43,853,641
Surface roads....	175,204,439	185,815,632	Dec., 10,611,193
Total.......	334,167,671	300,925,223	Inc., 33,242,448

This shows to how great an extent the elevated lines last year took business from the surface roads. While the former increased their business over 38 per cent., the surface lines fell off 5¾ per cent., the increase in the total business being about 11 per cent.

Or, to put it in another form, the elevated lines not only took all the increase of business—over 33,000,000 passengers—but they also took over 10,600,000 more away from the surface lines.

In 1887 the elevated lines carried 47½ per cent. of the up-and-down-town travel, and the surface lines 52½, while in 1886 the proportions were 38 and 62 per cent., respectively.

The principal causes for these changes have doubtless been the reduction of fares on the elevated lines, which was last year for the first time in effect for a full year, and the fact that for several years past the main growth of the city has been in a section too far removed from the business centers to be readily accessible by horse cars. The reduction of fares was, of course, the chief reason. Some further causes might be suggested, but they are of minor importance, and probably no single one had much influence.

The total passenger travel last year thus reached an average of 981,200 per day, the average movement up-and-down town being on an average 915,300 per day. The total movement thus closely approaches a million a day ; it will doubtless soon exceed that number. The number carried by the elevated lines averaged 435,500 a day.

That those lines are equal to the proper management of so large a traffic cannot truly be said. It must be remembered that the business is not at all evenly distributed ; a large part of it is concentrated both as to time and direction, probably one-half being carried within less than six hours of the day. The present system of elevated roads will, doubtless, remain an important part of the transportation system of the city ; they must necessarily serve their present purpose as the chief carriers for the longer distances for at least two or three years longer, until something better can be provided. With certain improvements—which there is not space here to indicate—they would serve for a longer time than that ; but it is certain that additional means of transportation must be furnished the city before long. Whether additional elevated lines, viaduct or arcade lines, or underground tunnel roads are to give the needed relief is the question now open for discussion.

Unfortunately for the city, the decision of this question is, under present conditions, very likely to be governed by unworthy motives. The danger is that some temporary makeshift may be the result, and that the real work will be left to be all done over again a few years hence.

New Railroad Building in 1887.

THE tables presented by the Chicago *Railway Age*, which usually has the earliest reliable information on this point, show that there were built in the United States last year 12,700 miles of new railroad, a greater mileage than had ever before been constructed in one year. The highest point previously reached was in 1882, when 11,550 miles were built. This brings the total mileage of railroad in the country at the close of 1887 up to 151,000 miles in round figures.

The new mileage of last year was very unevenly distributed, the Southwest leading with 5,150 miles, and the Northwest following next with 3,150. The Southern States added 1,700 miles, the Middle West, 1,650, and the Pacific States, 650, while the additions in New England and the Middle States were very small. Fully 70 per cent. of the new mileage was west of the Mississippi. Three States had more than a thousand miles each : Kansas, 2,055 ; Nebraska, 1,100 ; and Texas, 1,055 miles.

These facts show the character of the railroad building of the year. It was chiefly or very largely in new country. The building of roads to parallel the Eastern trunk lines has been, for the present, abandoned, and the work is now to develop and occupy the new regions of the West and Southwest. Most of this last year was done by the older

companies, whose lines already touched the borders of the new country. The trouble is, perhaps, as is often the case in this kind of building, that it has been overdone, and that in the anxiety of the companies to cover territory and secure traffic, two or three lines have been built into districts where one would have been quite sufficient. Too much of this unprofitable work has been done in Nebraska, Kansas, and some other States, as a study of a complete map would show.

Perhaps the most important line completed during the year was the Oregon line of the Southern Pacific Company, which gives the Pacific coast of the United States for the first time rail communication from its northern to its southern extremity.

It is to be noted that a very large part of the new mileage has been in comparatively easy country, and that there has been little work which required the solution of difficult problems in engineering. The exceptions to this have been one or two lines in Colorado, the Northern Pacific line over the Cascade Mountains, the Oregon & California Line, and two lines which required the building of bridges over the Missouri and the Mississippi. On the whole, however, it may be said that last year's new mileage was largely made up of easy and therefore comparatively cheap road.

The present indications are that railroad extension reached its height in 1887. There are a number of new lines in progress and still incomplete, which will be finished this year, and there are others which will be begun, so that 1888 will show very respectable figures, but it is not likely that it will equal its immediate predecessor.

NEW PUBLICATIONS.

A Collection of Diagrams Representing the General Plan of Twenty-six Different Water-works: Contributed by Members of the New England Water-works Association. New York; published by the *Engineering and Building Record.*

This publication is the result of the labors of Messrs. William B. Sherman, of Providence, R. I., and Walter H. Richards, of New London, Conn., who, acting as a committee of the New England Water-works Association, collected the sketches.

These sketches, which were contributed by different members of the Association, are intended to represent, in a condensed form, general views of the plans and constructions of water-works under varying circumstances. They are, as might be expected, of varying merit, some giving really admirable condensations of plans and facts in forms which can readily be taken in at a glance; others require more study, and in a few the facts are somewhat imperfectly represented. All of them have merit, however, and will repay a careful study by the engineer who is interested in such matters.

Of the 26 cities whose water-works are here represented, 23 are in New England, the only ones outside of that section being those of New Orleans, Wilmington, N. C., and Knoxville, Tenn. The water-works are chiefly those of the smaller cities and towns, Boston and New Orleans being the only large cities included in the collection.

The committee of the New England Water-works Association deserve much credit for originating the idea which has resulted in this collection, and also for the work done in securing the sketches and preparing them for publication. How great the labor required to make such a collection is, only those who have undertaken similar work can appreciate. The *Engineering and Building Record* has brought out the volume in excellent form. We are promised a continuation of this work hereafter, the committee having already three additional sketches contributed toward another volume.

Mineral Resources of the United States, 1886: by David T. Day, Chief of the Division of Mining Statistics and Technology, United States Geological Survey. Washington; Government Printing Office.

This volume is the fourth of the series begun in 1882, which was intended to give year by year a comprehensive view of the mining and mineral industries and resources of the United States. How extensive these are may be gathered from the summary given in the report, which places the value of the metallic products for 1886 at \$215,-364,825, and of the non-metallic mineral products (including coal, ores of all kinds, stone, etc.) at \$243,963,063; a total of \$459,327,888.

The general summary and statement is followed by a number of papers on various mining and mineral industries. These papers are for the most part by specialists in the several departments. Iron, coal, and coke are naturally given leading places, but much space is also taken up by interesting articles on copper, on lead, and on structural materials. A monograph on natural gas is furnished by Mr. J. D. Weeks, of Pittsburgh. A valuable supplement continues the summary of mining law begun in a previous year, especial attention being given in this volume to the laws of the States east of the Mississippi.

The previous volumes of the series (1882–85) have shown generally a decrease in values and either decreases or but slight gains in production. The year 1886 showed a notable increase both in production and in values of mineral products. A large part of the total gain was due to the increase in both production and prices of iron and steel, which was so remarkable a feature of the year.

BOOKS RECEIVED.

The Iron Age, for so long an authority in the hardware and metal trades, makes a new departure with the new year and changes from its old "blanket sheet" form to a page only a little larger than that of the Journal. The change is a very great improvement, making the paper of a convenient size to read and handle, and showing to much better advantage the fine typographical work which has always been a feature with it. The *Iron Age* has done much to deserve its present prosperity, and promises still better for the future.

The Locomotive Engineer is a new monthly paper issued by the American Machinist Company, and is intended especially for the benefit of locomotive engineers and firemen. It is edited by Mr. J. J. Hill, who was until recently an engineer on the Denver & Rio Grande Railroad. The first number of the new paper makes an excellent appearance; it is, apparently, inclined rather toward the practical than the theoretical.

Tables for Calculating the Cubic Contents of Excavations and Embankments; Volume II: by John R. Hudson, M. Am. Soc. C. E. New York; John Wiley

& Sons. This is the second volume of Hudson's well-known *Tables*. While it is a continuation of Volume I, it is so arranged that each volume is independent of the other and complete in itself. In the present volume the author gives several methods of computing earthwork quantities entirely different from those of the first.

A Text-Book on Roofs and Bridges: Part I; Stresses in Simple Trusses: by Mansfield Merriman, Professor of Civil Engineering in the Lehigh University. New York; John Wiley & Sons. (Price, $2.50.)

Fifteenth Annual Report of the Commissioner of Railroads of the State of Michigan, for the Year 1887: John T. Rich, Commissioner. Lansing, Mich.; State Printers. This report contains some unusually interesting statements; some extracts are given on another page.

Fifth Annual Report of the Board of Railroad Commissioners of the State of New York, for the Year Ending September 30, 1887: William E. Rogers, Isaac V. Baker, Jr., Michael Rickard, Commissioners. Albany, N. Y.; State Printers.

The Taylor Iron Works: Diary for 1888. New York; issued by the Company. The Taylor Iron Works have for a number of years issued a very convenient diary in pocketbook form, which, in addition to the usual calendars, pages for memoranda, etc., contains some 30 pages of condensed information very convenient for an engineer to have with him for reference. The diary for 1888 is in the usual form.

Our Merchant Marine: Its Condition as Shown by the Administration and the Admiral of the Navy: 1888. Issued by the American Shipping & Industrial League.

The Elasticity and Resistance of the Materials of Engineering: by William H. Burr, C. E. New York; John Wiley & Sons.

American Brake Company: Illustrated Catalogue of Locomotive Brakes. St. Louis; issued by the Company.

The Fowler Steel Car Wheel: Catalogue and Description. Chicago, Ill.; issued by the Fowler Steel Car Wheel Company.

Contributions.

THE MECHANICAL EQUIVALENT OF HEAT.

By Professor De Volson Wood.

It is now more than 40 years since the work which is the equivalent of a given amount of heat was determined by Joule of England. The results of those experiments were by no means uniform, but Joule, after a long series of experiments, and a patient and laborious discussion of the results, in which he seemed to give more weight to the smaller than to the larger values, finally concluded that the heat energy necessary to raise the temperature of one pound of water one degree Fahrenheit above the melting point of ice was equivalent to 772 foot-pounds of work. This value has been universally adopted by the scientific world, although more recently it has been admitted that that number is too small.

In 1876 a committee of the British Association for the Advancement of Science reported to that body that the mean 60 of the best of Joule's experiments gave 774.1 foot-pounds, but this number has not yet been used, at least to any extent.

Still more recently, about 1880, Professor Rowland made a critical examination of the specific heat of water from about 40° F. to above 90° F., determining the value for each degree and the corresponding value of the mechanical equivalent.

The investigation included the comparison of the air thermometer with the best mercurial thermometer, and a comparison of the mercurial thermometers used with the one used by Joule. The results of these experiments were published in the proceedings of the American Academy of Arts and Science, 1880. It is observed that when Joule's experiments are reduced to Rowland's thermometer and for the latitude of Baltimore, they agree almost exactly with those of the latter, the latter being about $\frac{1}{1000}$ of the mechanical equivalent larger.

But the interesting and unexpected discovery was made that the specific heat of water was greater at 40° than at 80°, and that it appeared to be a minimum near the latter point. This was contrary to the law given by Regnault's experiments, for, according to the latter, the specific heat of water increases from the melting point of ice as the temperature increases, and as this law was used by Joule in reducing the equivalent from 60°, the temperature near which his experiments were made, to its value at the temperature of ice-cold water, the resultant value would be somewhat less than the value found by direct experiment. The same remark applies to the value given by the committee of the British Association; hence, not only is 772 too small, but 774.1 is also too small.

There are physical reasons for not using the melting point of ice from which to measure the degree of rise of temperature. It is a critical point, and the water at that point may be absorbing heat preparatory to a change of state of aggregation. The condition of maximum density is a much more desirable point of reference. Water under the pressure of one atmosphere has a maximum density at 4° Centigrade, or 39.2° F. Omitting decimals, Rowland's investigations gave 778 as the mechanical equivalent of heat at 39.2° F., according to the mercurial thermometer, and 783 according to the air thermometer. In my recent work on thermodynamics I have used 778, not merely because that was one of the values found by Rowland, but because it agrees fairly well with the result found by other means, and also because we may, when using that number, consider the specific heat of water as constant without much error; whereas if 783 were used, the variable specific heat ought to be taken into account. We also notice that Rowland found 778.4 for the equivalent at the latitude of Baltimore for the air thermometer when the temperature of the water was 60.8° F.

We are confident that the old number, 772, will sooner or later be abandoned and a larger value used, because nearer correct; but it remains to be seen whether 778 will be adopted. It is apparent that for accurate scientific work the value used should be one determined in reference to the air thermometer, and for a particular degree of the scale, and all departures from uniformity—such as a variable specific heat—be determined.

THE PRINCIPLES OF RAILROAD LOCATION.

By Professor C. D. Jameson.

(*Continued from page 14.*)

CHAPTER VIII.

VERNIERS.

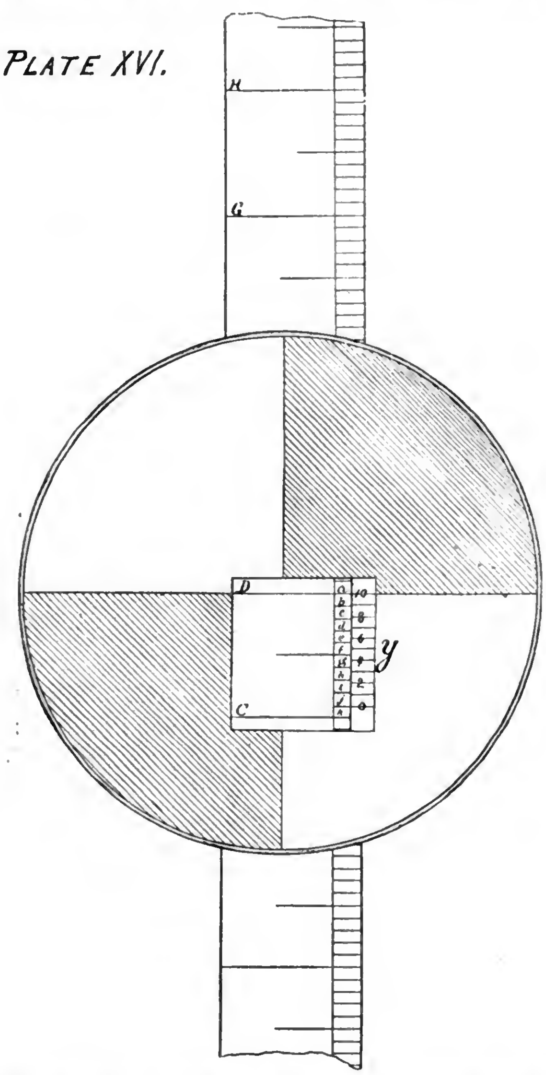
The Vernier has been referred to in several of the descriptions of instruments used in location. Its use is so general that a special description is given below.

A vernier is a contrivance by means of which smaller divisions of distance are read than the actual divisions made on the scale or rule. By its use exceedingly small divisions can be read by the naked eye.

On railroad work the vernier is used upon a level rod in taking turning-points and upon the transit in measuring angles.

The principle of the vernier is as follows: Take any scale, as Plate XVI, which represents a part of the level rod. The large divisions *A*, *B*, *C*, *D*, etc., are tenths of feet. These tenths of feet are divided each into 10 parts, mak-

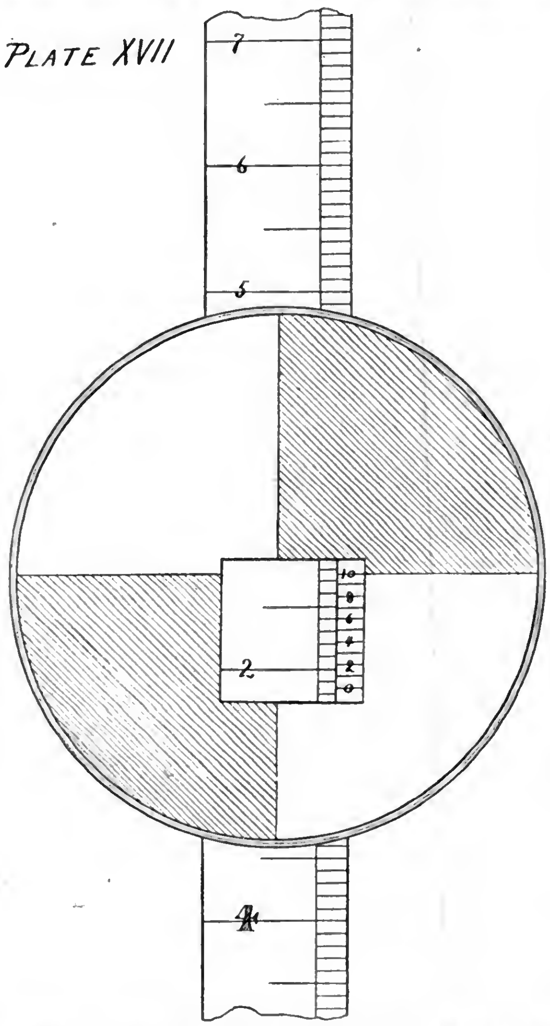
PLATE XVI.



ing .01 of a foot. Now, it is desired to measure distance to the thousandth of a foot. If the smaller divisions, or .01 ft., are to be divided into 10 parts, making .001 ft., each of these divisions would be so small as to be scarcely perceptible to the naked eye, and this subdivision, owing to the increased amount of work on the rod, would also increase the cost very much. Now, the object of the vernier is to permit the reading of .001 ft. without the necessity of dividing each hundredth of a foot into 10 equal parts. The way in which it is accomplished is as follows:

The rod is divided into hundredths of a foot, *a*, *b*, *c*, etc., then the vernier scale *y* is made equal in length to nine of these small divisions *a*, *b*, *c*, and is divided into 10 equal

PLATE XVII



parts. Then 10 equal parts of a vernier scale are one-tenth shorter than 10 equal parts of a rod scale, and, consequently, each small division of the vernier is one-tenth shorter than each small division of the rod—that is, the difference between the divisions on the vernier and those on the rod is .001 ft.

Numbering the divisions on the vernier scale from zero to 10, as shown in Plate XVI, then the number 10 on the vernier scale comes opposite the ninth division on the original scale, and if the rod be slipped down until No. 1 on the vernier scale corresponds with No. 1 on the original scale, then the rod has been moved .001 ft. In like manner, if the rod is moved so that No. 6 on the vernier scale corresponds with No. 5 on the original scale, it has been moved .006 ft. Thus it is very easy to read with the naked eye down to .001 ft., and with much more exactness than if the original scale had been actually divided into thousandths of feet.

The vernier was invented in 1861, and takes its name from the name of the inventor.

Plate XVIII represents the two plates of a transit, the vernier scales *A* and *B* diametrically opposite each other. These verniers can be divided in a number of ways, and

the most common way is as follows: The outside circle is divided into degrees and half degrees. Take 30 of these smallest divisions on the outside circle and make the vernier equal 29 of them, and divide it into 30 parts; we are thus able to read to minutes in angular measure.

PLATE XVIII

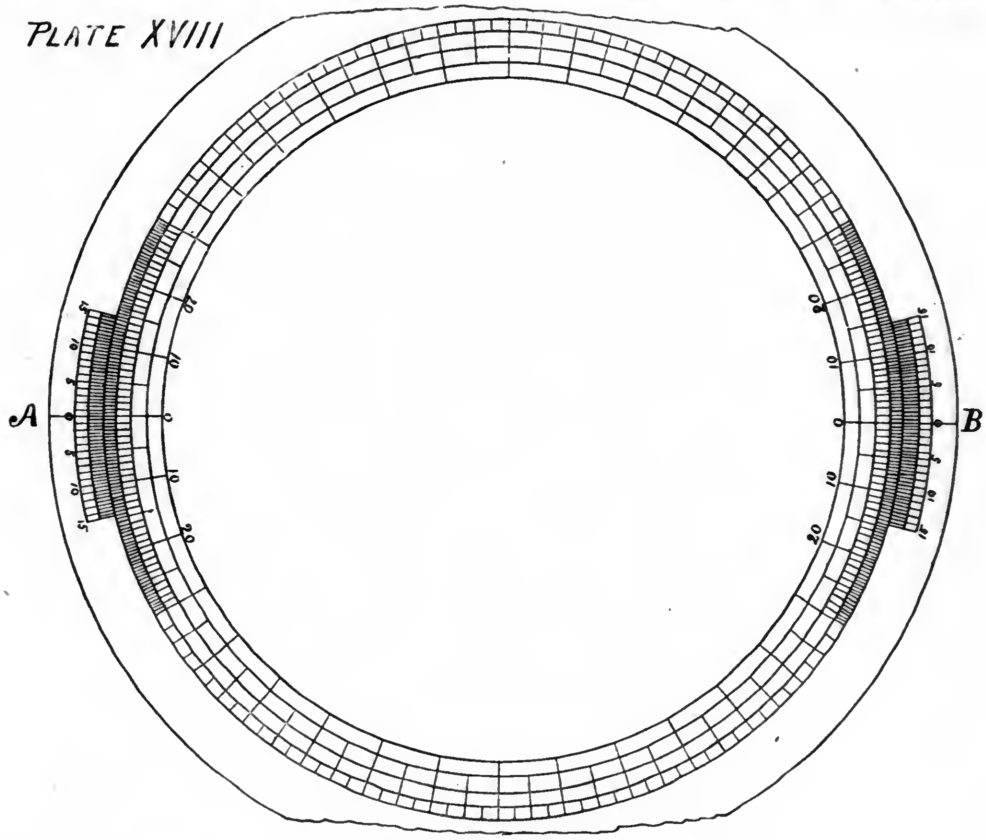
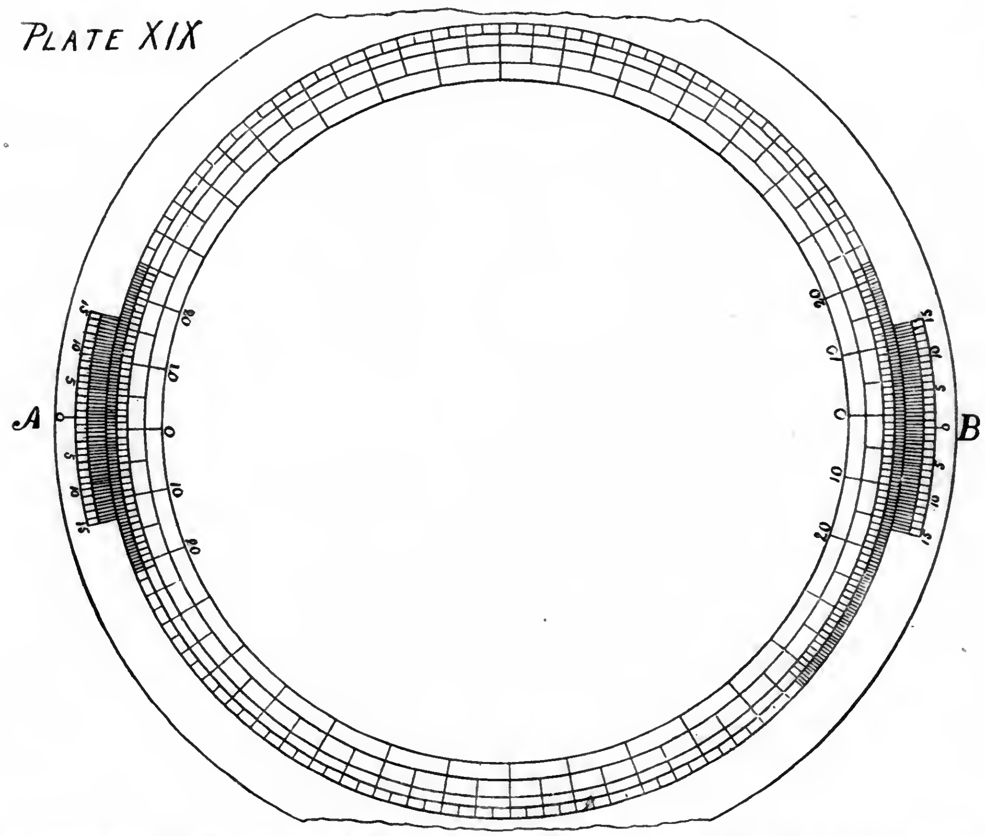


PLATE XIX



Where more exactness is required the circle is divided into degrees and thirds of a degree (20 minutes). Then 20 spaces on the vernier are equal to 19 spaces on the circle, which reads to minutes, or if it is required to read the half minutes or 30 seconds, then 40 spaces on the vernier are made equal to 39 spaces on the circle. In the same manner the most minute divisions of angular measurement can be read. Of course the only limit to this is the length of the diameter of the circle, because as the divisions become finer and finer, on an ordinary transit they become too fine for accuracy and increase the cost, so that they seldom read to less than 30 seconds.

The transit, when it is to be used for stadia measurements, frequently has a vernier divided on the decimal system, so that any reading of angular measurements is taken in de-

grees or decimals of degrees. The advantage of this, in the case of stadia measurements, is that under ordinary circumstances all the angular measurements are taken from the azimuth to the right, the same as the hands of a watch, through the whole 360 degrees of the circle, and in notes taken in stadia work there is much addition and subtraction to be done. It facilitates the calculations very much if the readings are in degrees or decimals of degrees rather than in minutes or seconds.

The numbers on the front of the level rod, running from the bottom up, are read in feet, tenths and hundredths of feet. In using the vernier upon the level rod, the reading is taken in the following manner: The target is moved up or down until it coincides with the center line of the telescope and then clamped. The full number of feet, tenths

PLATE XX

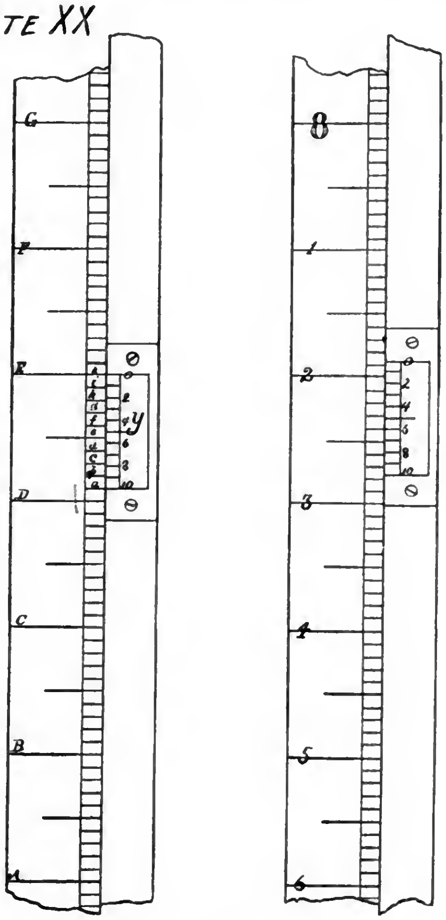


Fig. 1 Fig. 2

and hundredths of feet coming below the zero is read. The vernier scale is then followed down until some division on the scale coincides exactly with the division of the scale on the rod, and the number of this division on the vernier scale gives the number of thousandths of feet. For example: Plate XVII represents the level rod when the reading is about to be taken. We see below the zero of the vernier scale, which is marked 0, that there are four feet with .2 and .07 ft. Then following down the vernier scale we see that the division marked 6 on this scale corresponds exactly with the line of division on the rod scale, therefore showing that the center of the target is .006 ft. above the last hundredth division, below the zero of the vernier scale, and the reading would be 4.276—that is, the center of the target is that distance from the bottom of the rod.

Plate XX represents the vernier on the side of the level rod. The numbering on the rod reads from the top down, as the back of the rod is pushed up, the vernier remaining stationary on the front part of the rod, as shown in fig. 2, where the reading is 8.186.

CHAPTER IX.

PRELIMINARY SURVEYS—PURPOSES.

The object of a PRELIMINARY SURVEY is as follows: Having become thoroughly acquainted and familiar with that section of country through which the railroad is to be built, by means of the reconnoissance, the engineer then has in his mind one, and in some cases two or more, lines between the terminal points which appear to him to present the fewest obstacles to the construction and operation of a railroad. One of the objects of the preliminary surveys is to actually put on the ground as many of these possible lines as may be deemed expedient. The engineer must use care never to pass over what might be the best line. Although in the chapter on reconnoissance it is stated that a good locating engineer should be able to decide which is the best line by the reconnoissance, still, if there is any doubt, the other lines should be surveyed, as this will only necessitate a slight additional expense, while by neglecting this survey an everlasting expense may be entailed upon the railroad.

From the data obtained by these surveys there can be made an exact and mathematical comparison of the relative merits of the different lines.

Another object of the preliminary surveys is to obtain such data on each side of these preliminary lines that an exact map of the country can be made of such a width as to include within its limits the best line for a railroad, in all its details, between the terminal stations. This map should show all the topographical features of the country—that is, all the hills and valleys and other changes in the surface of the ground, the position and direction of all the water-courses, and the position and direction of all the fences between different properties, with the names of the different owners. The last in regard to property is important, as will be seen when we come to the question of Right of Way.

This map should also have on it the contour lines, in order that a paper location can be made. What contour lines are and what a paper location is will be fully explained further on.

Now, as has been explained, preliminary lines are lines run between the terminal points in the field in those positions which from the reconnoissance appeared in the mind of the engineer to present the least obstacles to the construction and operation of the future railroad.

These preliminary lines are run with much less care as to their actual location than a final location, but not with any less accuracy.

On the preliminary lines there are usually no curves put in, but the line is made up of a number of straight lines of different lengths, meeting at different angles, as shown in Plate XXI, fig. 1.

Let *A B* be the terminal points; then one of the preliminary lines run between them could take the form of *A c d e f g h i j B*. The length of the different lines *A c*, *c d*, etc., and the size of the angles *a c d*, *c d e*, etc., of course depends upon the topographical features of the country. In running these lines upon the ground enough data must be taken to enable the engineer to make accurate plans and profiles of each line. By the plan of a railroad line (Plate XXI, fig. 1) or a section of country we mean that we show on paper exactly what we would see if

we were above that section of country and looking down upon it—that is, we see the horizontal length and direction of every feature on it, but we do not see any vertical changes—that is, we do not see any of the ups or downs of its surface.

In the profile (Plate XXI, fig. 2) of a line, on the contrary, we are supposed to be looking at the line from one side, so that we see only the vertical changes of direction and none of the horizontal changes.

In order to plot a preliminary line we must know the exact length of each of the short lines of which it is composed, and these can be measured either by means of the measuring chain or the stadia. Also, each of the angles at which these short lines meet must be accurately measured, and this is done by means of either the transit or surveyors' compass.

In making the profile of a line, the data that we need are the height above some known point or plane of every point in the line where the surface of the ground changes, and also the horizontal distance between these points.

We will suppose Plate XXI, fig. 2, to be the profile of a

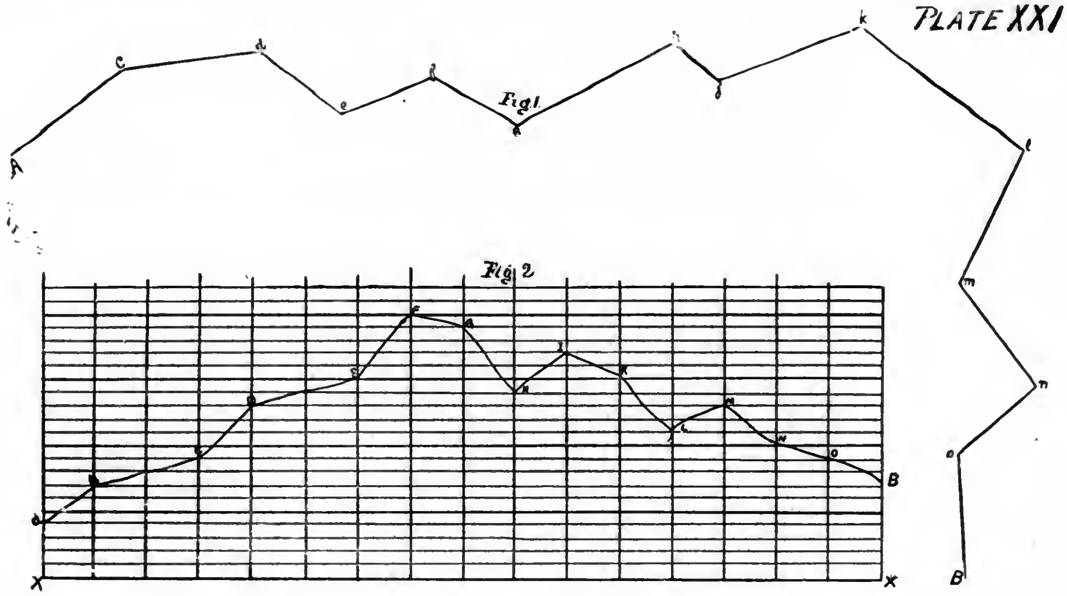
The methods used in the field on preliminary surveys may be divided into two classes :

1. The one which until very recently has been in general use—that is, running as many lines as may be deemed necessary by means of the surveyor's compass or transit, and then getting the data for the profile of these lines by means of the wye-level, with the necessary topography on each side of the selines by means of the wye-level, the cross-section rod, or the slope instrument, when both the horizontal and vertical distances are actually measured on the ground.

2. Getting horizontal distances and direction and vertical distances by means of a transit with stadia attachment. This is the more modern method, the advantages of which, under certain circumstances, will be explained in the proper place.

We will describe these two methods in the order named. On railroad work the surveyor's compass is very little used now, owing to the fact that such great improvements have been made of late years in the manufacture of transits, particularly in the United States, that to-day the railroad

PLATE XXI



line *A B*—that is, it shows where and exactly how much the line *A B* runs up and down-hill, and to make this profile we must know the height of each point, such as *B C*, above some fixed point, like *X X*; and these different heights are found either by means of the wye-level or the stadia.

When the wye-level is used, the heights are usually taken at every chain or station. Where feet are the standard of measurement the chain used on railroad surveys is 100 ft. long ; where the meter is the standard the length of the chain used varies, but, although it is rather short, a 20 meter chain is the one usually used.

When the stadia is used the heights are taken only at each important change in the direction of the surface of the ground, as the stadia gives both the vertical heights and horizontal distances at the same time.

CHAPTER X.

PRELIMINARY SURVEYS—METHODS.

Having thus fully explained what data must be obtained on a preliminary survey, and having described and explained the various instruments used, we will now show the methods used in the field by means of which the required data are obtained with the instruments used.

transit with all the stadia attachments is a light, strong, and simple instrument, with very little liability to get out of order, and by a good transitman can be used as quickly as a compass, and much more data, and much more accurate data, can be taken than with a surveyor's compass. There are some circumstances under which a compass can be used with advantage, such as running side lines or "offsets" from a main line. A smaller number of men is required with a compass than with a transit, and there is this advantage, that in using the compass all the lines are run by means of the magnetic needle, while with the transit all lines are usually run by means of back-sights. Therefore, in using the compass any error that is made in taking the bearing of a line is confined to that line, and goes no further ; while with the transit any error that is made in reading an angle is increased in each following angle, and grows larger and larger as the work progresses. Still, as every line run with the transit can be checked by means of the needle, there is no excuse for one of these accumulative errors.

Before running a trial or preliminary line through a country, the engineer should decide within certain limits what the rate of grade is going to be.

From the data which have been obtained on the reconnoissance there should be very little difficulty in doing this.

For instance, if the line is to run up a valley, and in order to cross the range is obliged to run through a certain pass, we know from the reconnoissance the height of this pass as compared with some point at the foot of the hills where the line can begin to climb, and we also know approximately the distance between these points. We can, therefore, with the difference in elevation and the distance between them, get the rate of grade of any straight line drawn between the two points. But as any line upon which it would be practicable to build a railroad would in hardly any case be a straight line, it would be longer, and therefore the rate of grade to reach the same elevation would be less. There is, however, another point to be considered here. We will make only mention of it now, as it will be fully discussed later. This point is, that in any continuous grade or any grade where it is desired to use the same amount of power to haul the same train up the entire length, there must be a "let up" in the grade on every curve. There is a certain amount of resistance to moving a train due to a grade, and also a certain amount due to each degree of curvature, so that in order to make this resistance to motion, or, in other words, the power required to haul the train, at all points equal, the rate of grade on curves must always be reduced so that the resistance due to the curve plus the resistance due to the reduced grade on the curve shall be equal to the resistance due to the grade alone on a straight line. This is called "compensation for curvature," and will be treated of under that head.

It will be seen that this compensation for curvature reduces the actual rate of grade and requires a greater length of line to overcome the same difference in elevation than if the grade was absolutely continuous. All of this has to be taken into consideration when deciding upon what is to be the trial rate of grade.

Now the engineer can decide exactly what rate of grade he wishes to try, or he can run what appears to him to be the most practicable line, and when the profile is plotted find by trial on the profile what grade will best fit the ground. In case a particular grade is decided upon, the method to be followed in the field is to run that line on the ground which will give approximately the required rate of grade without any cuts or fills. In a rough country this line will, of necessity, be an extremely crooked one. When this line has been run and plotted on paper, then a line with suitable curves is plotted over it, and the more nearly this second line corresponds to the first, or grade line, the less work there will be on construction.

In running this grade line on the ground, when a ravine or other obstacle is encountered which it is obvious would take too great a length of line, or as it is called, "development," to run around, then the line is at once located over or under it. In the same manner, when any of the obstructions met with are of such a slight nature that practically they offer no impediment to the construction of the road, the line is simply run over them.

Whenever a line is, from the topographical formation of the country, obliged to pass a certain point in a range of hills or mountains, the engineer should always commence the line at the pass, and run backward, if necessary, to the more open lower country.

The advantage of this is, that the point where the line must cross the summit at the pass is fixed, and cannot be changed, and also the rate of grade is within certain limits, if not absolutely, fixed, while the point where the line leaves the open country and begins to climb is not absolutely fixed, and within certain limits can be shifted from one side to the other as the exigencies of the rough country beyond require.

By commencing at the pass with the depth of cut that has been decided upon, and then dropping down with the required grade, we obtain at once the two elements that are fixed, and leave to the topographical formation of the country only the third element (that is, the point where we enter or leave the lower land), and which can be varied. On the other hand, if we start at a fixed point at the foot of the hills and run up on a fixed grade, we may have to run any number of lines before we hit the pass at the required elevation, either by not developing enough or too much, as the case may be.

Under many circumstances, however, each end of the line is absolutely fixed. In this case, two lines can be started, one from each end, and run until they intersect or until some point is reached where they can be shifted from side to side without great detriment to the cost of construction, and thus joined. In case there is no such point as this, or, at least, no such known place, that can be passed by the proposed line where it can be shifted from side to side, then the only way is to run from one fixed point to another and make the proper development as near as may be, and then by repeated trials correct any errors.

In running a line of any particular rate of grade on the ground it is not necessary to use the wye-level except as a check and, of course, to obtain data for the profile; but by means of the vertical circle on the transit the center line of the telescope can be set at any required angle, and by finding the height of the center of the telescope above the ground each time it is set up, and marking this height on the rod, a continuous grade of any length may be run at once.

When the telescope is used in this manner it is a good plan to use a level-rod in the place of the lining rod, as the target can be set each time at the height of the center of the telescope.

CHAPTER XI.

THE SURVEYING PARTY.

The party on a preliminary survey is as follows:

Chief of party	1	
Transitman	1	
Chainmen	2	
Rodmen	2	
Stakemen	2	
Axemen	2	= 9
Leveler	1	
Rodman	1	= 2
Topographer	1	
Assistants	2	= 3
Cook	1	
Teamsters	2	= 3
Total		18

The duties and methods of work of each are as follows:

The entire party is under the direction of the Chief of Party, who is held responsible for the amount and class of work which is done, and who reports directly to the Chief

Engineer or Chief Assistant. This Chief of Party has not only to see that the work progresses with all possible speed and accuracy, but also has many other duties. He must see that his party is properly lodged and fed, and, above all, that perfect discipline is maintained; that each member of the party not only understands what his duties are, but that every night all these duties required have been performed and none of to-day's work left for to-morrow.

The Chief of Party has received full instructions from the Chief Engineer as to the lines that are to be run and the methods to be used in the field. He is well acquainted with the country, and has the best procurable maps of it. Before starting any work in the field he must have a clear and comprehensive idea of what he has to do and exactly how it is to be done. The Chief of Party knowing all this, the work commences and proceeds as follows:

The Chief of Party shows the Transitman the point from which the line is to start. If this point is not already well defined it must be made so before the work proceeds. The most common way is to drive a short stake called a "plug" (about 4 in. long and 1½ in. in diameter) firmly into the ground at the point, the top of this plug being even with the ground or a little below it, and in the top of this plug directly on the transit point a tack or small nail is driven in, as in Plate XXII, fig. 2.

In this manner the point is in very little danger of being disturbed either by accident or malice. But in addition to this precaution all transit points which it is desirable to save, or which may be used again, should be "tied in"—that is, they should be referenced to points on some permanent objects, such as buildings, trees, etc., in such a manner that if the plug gets moved in any way the point can be re-established with accuracy and speed. The usual way of tying in transit points is as follows (Plate XXII, fig. 1): Let *P* be the transit point which it is desired to tie in, and *P L* the direction of the line which is being run. Then with the transit at *P* and the telescope set on the line *P L*, we turn off the angle *T P L* to some tree or permanent object as *T*, and then on another tree *R*. The nearer the angle *T P R* is to a right angle the better. These trees *T* and *R* should be blazed on the sides facing *P* and a tack point made, as shown in Plate XXII, fig. 3, where *A* is the tack point driven into the blaze and *B* is a circle round the tack point made with keel or whatever the stakes are marked with. While the telescope is sighted on the tack points in the trees the plugs *s s* are driven about half way between the trees and the transit, or the telescope is reversed and the plugs *d d* put in the other side of the transit. The points where these plugs will be driven will, of course, depend upon the topography of the place. These plugs have tack points put in the top, and the distances from the trees to their respective plugs are measured and noted in the transit book. Then in case the point *P* becomes lost, the transit is set up on one of the plugs and the telescope sighted on to the tack point in the tree *T*. Then in this line two plugs, *x* and *y*, are driven with tack points, one on each side of where the original point *P* was. The transit is then set up over the other plug *d* or *s* and sighted on the tack point in the tree *R*.

A small cord is stretched from *x* to *y*, and then the lining rod is moved along this cord until it is in line with *d R*, when a plug is driven, and the tack point on this plug, being exactly at the intersection of the two lines *d T* and *d R*, is the original point *P* wished for.

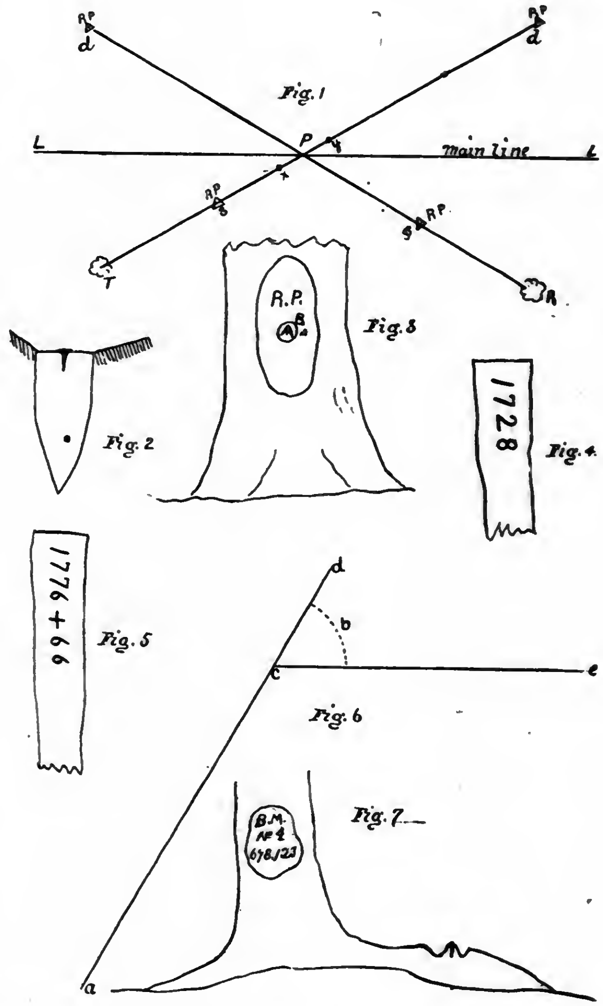
The trees *T* and *R* should be far enough from the main line to give sufficient height of line for a back-sight, and also to be outside the line of clearing the right of way.

This tying in and preservation of transit points applies not only to the starting-point, but to all transit points on the line that would be needed if it should become necessary to retrace the line at any time. At one side of the plugs *s s* or *d d* and 2 ft. from them should be driven stakes marked *R P*. The side of the stakes on which the letters are should face the plugs.

Every transit point that is put in should be guarded in the same way by a stake properly marked at one side. If the line starts from a line of railroad already built, care must be taken to make sufficient measurements to any switches, buildings, culverts, or any other permanent objects which will enable the draftsman to connect the new line to the plans of the old line without any trouble.

In running through towns care must be taken to designate exactly all street crossings, with all necessary angles and measurements.

PLATE XXII



In running preliminary lines, stakes should be put in every chain and numbered. The usual way is to call the starting-point 0 and then number 1, 2, 3, etc.

This is the manner when the 100-ft. chain is used. When the 20-meter chain is used the starting-point is 0, and then each 20 meters is called two stations, so that the numbers run 0, 2, 4, 6, etc., a station being 10 meters long and stakes being put in only at every other station.

The stakes should be about 2 ft. long and driven straight and firmly in the ground. The side of the stake that has

the number on it should always be turned toward the preceding stake, so that any one in walking over the line in the direction in which it was run will be able to read the numbers. This, of course, does not apply to the guard stakes at the transit points, the positions of which have already been described.

The stakes should be numbered as follows (Plate XXII, fig. 4): The number beginning at the top of the stake and running toward the point. One side of the stake should be smoothed, so that the number can be written on it clearly. The usual material for marking stakes is keel, for the reason that rain does not wash the mark off.

When the starting-point has been decided upon and marked either by means of a plug or in some other way, the transit is set over it. While this is being done the Chief of Party goes ahead with a lining rod, and by means of this rod, which he sticks into the ground at any desired point, indicates to the transitman the direction in which the line is to be run. As soon as the transitman has set his telescope upon the rod (being sure the zeros of horizontal plates are together) the chainmen begin to chain toward the rod. It is not necessary that these stakes that are driven in every chain should be lined in by the transitman, when the chainmen have a fore-sight to chain to. In this case the lining rod put in the ground by the Chief of Party is the fore-sight, and the rear chainman each time lines in the head chainman. If the chainmen have had any experience no time or accuracy will be lost.

In regard to chainmen, other things being equal, always put the quicker or more lively of the two ahead, and have it understood that the rear chainman is never to drop his end of the chain; then he is obliged to move as quickly as the head chainman, no matter how lazy he may be.

Before being used the chain should always be tested with a steel ribbon as to length. The chainman must always be sure that the chain has no kinks in it, and that it is held straight, taut, and as nearly horizontal as possible. When the slope of the ground is so great that it is impossible for the chainmen to hold the full length of the chain horizontal, then let them use only half or quarter of the chain at a time. The down-hill end must be raised until it is level with the other end, and a plumb-bob used to mark the place on the ground. Care must be taken in using half or quarter chains that all the stations are the regular 100 ft. long, as without this care it is very easy to lose 25 or 50 ft. in the numeration. Chaining up or downhill in the above manner is called "breaking the chain."

The head chainman may, and usually does, carry a lining rod with which to take points when too far from the transit for the stake or plug to be used. Under some circumstances a head rodman keeps along at the head of the chain for the purpose of lining in the stakes.

As the chaining proceeds, the stakeman having his stakes properly numbered and ready, drives them, as before directed, at every chain. When the point that the Chief of Party indicated has been reached, a plug is put in with tack point and guard stake. On this stake should be noted the number of the station if the plug comes at a full station; if not at a full station, the stake should be marked with the number of the preceding station plus the distance from this station to the plug, as shown in Plate XXII, fig. 5. Then Station 1777 would be 34 ft. from the transit point in whatever direction the line runs.

The object of thus numbering the stakes is that all the stations may be of equal length, so that whatever number is on a stake will indicate the distance of that stake from o.

The transitman takes the magnetic bearing of the line and notes it in his transit book. He then takes his transit and moves on to his first transit point, the Chief of Party in the meantime having gone ahead to indicate the direction of the new line. The rear rodman stops at the point just left by the transitman.

When the transit is set up on the new point the first care after leveling the instrument is to see that the zeros of the horizontal plates are together; then set the vertical cross-hair on the rear rod, which should be held vertically by the rodman on the last point as a back-sight until the transitman signals "All right."

In sighting upon a rod the transitman should always sight as near the foot of the rod as possible, as in this way he is more sure to near the actual point than in sighting at the top of the rod in case the rodman holds the rod out of plumb. In holding a lining rod the rodman should stand directly behind it with his feet apart, and hold the rod lightly with both hands. The lower end of the rod, being shod with metal, will by its own weight bring the rod vertical if held so lightly that it is free to swing a little.

The principal duty of the rear rodman is to so watch the transitman for signals that no time may ever be lost in vain endeavors to attract his (the rear rodman's) attention. When the telescope is set on the back-sight it is reversed, and the transitman is prepared to start in any direction with his line.

When the new direction has been given him he unclamps only the upper plate and sets his telescope on the new fore-sight, and then from the horizontal plates he reads off the number of degrees of the angle between the two lines, as shown in Plate XXII, fig. 6. In this let *a d* be the first line and *c e* the second line, then the angle that is measured is *d c e*. The magnetic bearing of the second line should also be taken. In taking these bearings the reading of the needle is not as accurate as the reading of the degrees and minutes of the angles of intersection, but they serve as a check on the measurements of the angles, and make any large error impossible.

The number of axemen and stakemen needed depends on the character of the country through which the line runs. In an open country, where long sights are possible and little or no clearing is to be done, two or more stakemen may be needed, and only one axeman, while in a rough, wooded country the reverse may be the case in regard to both axemen and stakemen, as fewer stakemen are required when the progress is slow.

The duties of the axemen are to clear away any obstacle that may obstruct the view of the transitman, such as brush, trees, branches, etc. Care should be taken to make the path cleared as narrow as possible, and at the same time to make the clearing thorough, so that the axemen need not be called back to do any work a second time. In axemen experience is of great advantage, both as to cutting on a line and making the cut thorough the first time. On preliminary lines too much time should not be lost in cutting down large trees. The line should be shifted to one side or the other for any tree over 6 in. in diameter, or else a new line started. The object is not to lose any time.

In a rough, wooded country it often happens that the Chief of Party is unable to see the transitman when he wishes to give a new direction. In this case the direction

is given by shouting. With some care and practice a transitman can follow very closely the sound of a voice.

All members of an engineering party should have a perfect understanding as to a code of signals by either the arms or flags, by means of which they may to a greater or less extent communicate with each other when too far apart to be able to make themselves heard when speaking. There should always be as little shouting and noise as possible. It delays the work and shows great ignorance on the part of the workers.

When several lines are run between the same terminal points they should be distinguished one from the other both in the notes and on the stakes in the field thus : *A* or *B* or *C*.

Very often during a preliminary survey part of a line may be changed, and as it would be a great loss of time to change the whole numbering of the line, the method used is then as follows : Let the first line be *A B*, 900 ft. long and approximately straight. Then we will suppose that between stations 3 and 8 there is a spur of a hill which it is advisable to run around on the line 4′, 5′, 6′, etc., until it rejoins the original line at station 8. The numbering of the stakes is continued on the new line the same as on the original line up to station 7′. Then as station 8 is in the original line and we wish the numbering to continue the same in that line, we make in this case what is called a "long station"—that is, we measure the distance from station 7′ of the new line to 8 of the old line and call it one station. In this case this would be 180 ft., and a note must be made in the note-book that station 7′ is 180 ft. long. In case the new line had been shorter than the old line, then the last station would have been a "short station," and must be so noted in the note-book, with its actual length.

When a new line starts from an old line and runs in any direction so as to become in itself a line and not a mere change in the original line, then it has a numeration of its own, and in the notes the points where this line meets or crosses any other line must be noted as follows :

Station 10 + 40 line *A* = to
Station 0 line *B*. Or
Station 123 line *A* = to
Station 23 + 4 line *C*, etc.

Whenever the surveyor's compass is used for running lines, the manner of proceeding is about the same as has been described for the transit, with the exception that no back-sights are taken, as the direction of all the lines is taken by the magnetic needle, and not by direct angular measurement. The use of this instrument, as has been said, is now, on railroad work, confined principally to the running of cross-section lines—that is, lines run at more or less of an angle with the main line for the purpose of obtaining topographical data.

The Chief of Party should give especial attention to the determination of the length of the bridges that may be necessary, and the openings of culverts. He should keep a note-book containing all this data, also all the data he can collect in reference to the drainage of the area that is passed over, the cross-section of the streams when at their highest, and all the general information possible. These notes should be made as clear, full, and explicit as possible, containing all the local names of streams, rivers, etc., and all of these should be referenced to the nearest stake in the line of the survey.

Every night the transitman must plot all the work done by him during the day. This plot should then be carefully examined by the Chief of Party to see if any changes are to be made or if the work is to proceed.

(TO BE CONTINUED.)

Guard-Rails on Bridges.

THE Massachusetts Railroad Commission has recently issued a circular to the railroad companies of the State on safety at railroad bridges. This circular speaks of guard-rails and guard-timbers as follows :

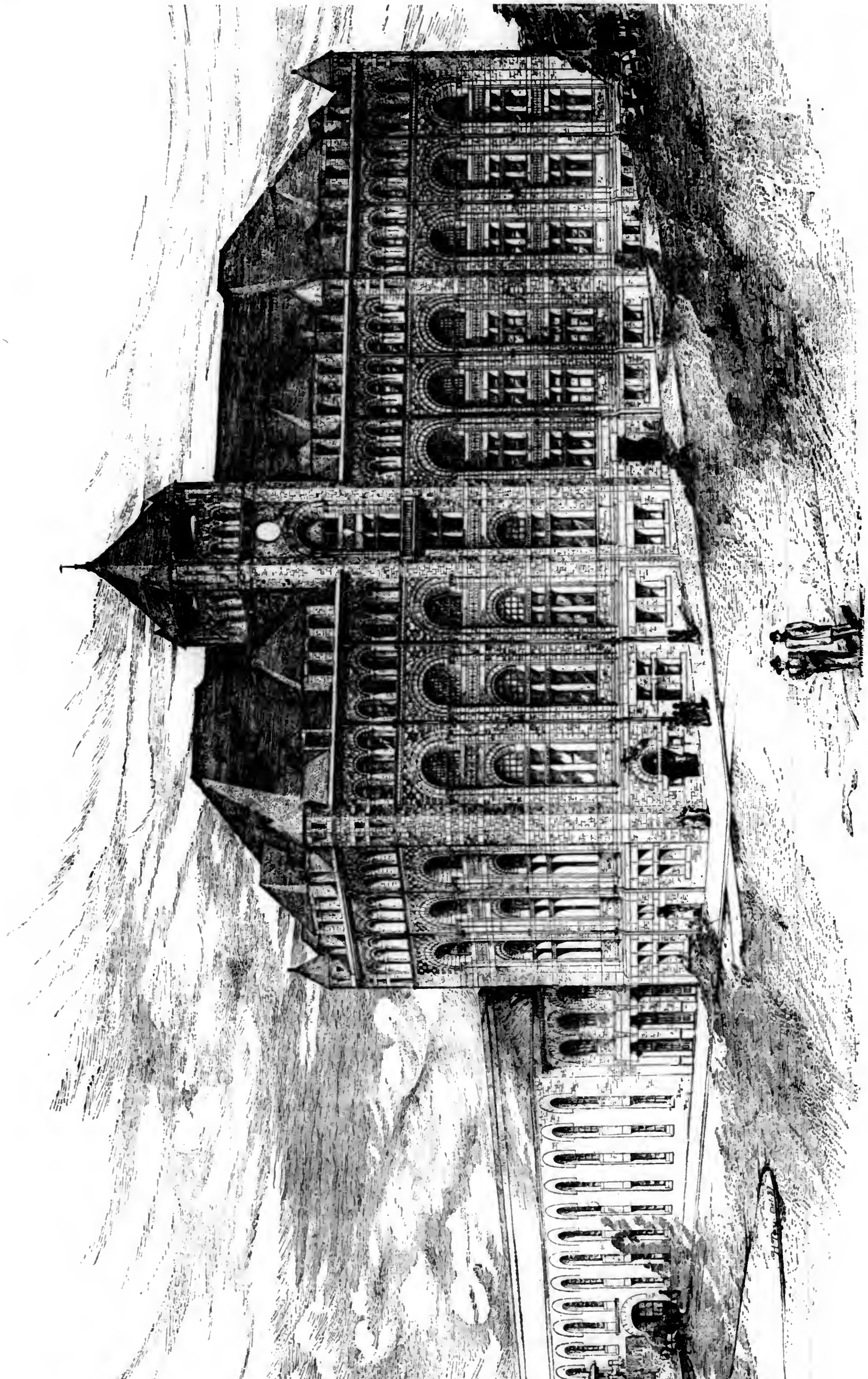
The object of the guard-rail is to prevent a derailed truck from getting far enough off the track to strike any portion of the girder, or from becoming twisted so as to lead to further derailment. The floor of every bridge should, moreover, be so constructed as to be able to carry safely any derailed car or engine ; and for this purpose, the ties should be substantial timbers, measuring not less than 6 by 8 in., and spaced not more than 8, and preferably 4 or 6 in. in the clear. Efficient guard-timbers outside of the rails should also be provided, notched on each tie and bolted at short intervals—the object of such timber being to hold the ties in place, and to keep them from being bunched by a derailed wheel. Instead of notching the guard-timber over the ties, it may be simply bolted, and spacing-blocks securely fastened between the ties to keep them apart.

In addition to such guard-timbers, guard-rails are requisite, so arranged as to bring a derailed truck nearly back to its proper position, and guide it across the bridge without allowing it to deviate more than a few inches from the rails. For this purpose, outside guard-rails and inside guard-rails are in common use.

The ordinary arrangement of outside guard-rails is as follows : The guard-timbers before described are placed 6 or 8 in. from the rails, and are sometimes protected with an angle-iron fastened to the corner. At the ends of the bridge, or on each track at the end at which trains enter upon the bridge, curved rails extend from these guard-timbers, flaring outward and resting on long ties.

The Board recommend the use of the inside guard-rail, placed with a clear space of from 7 to 10 in. between the heads of the guard-rail and the track-rail, securely spiked to the ties, and with ends running to a point in the center of the track on the side from which trains approach. The distance of this point from the end of the bridge should vary in different cases, but should not be less than 30 ft., and preferably 60 ft. on important bridges. If the approach is on a curve, the guard-rail should be carried further ; and on sharp and short curves it is advisable to extend them entirely around the curve, or to run them to a point 30 or 60 ft. from the bridge, and from this point to carry a single rail in the center of the track around the curve. The point of the guard-rail should be protected by an old frog point or by a bevelled wooden block to prevent any hanging chain from catching on the end. The distance between the track and the guard-rails should be sufficient to allow a wheel to run between them without crowding either rail, or from 7 to 10 in.

The Board consider that this form of guard-rail is much more efficient than the outside guard-rail in bringing a derailed truck back to its proper position. On many roads the outside guard-rails extend but a short distance beyond the ends of the bridge, and are frequently curved abruptly so as to be nearly at right angles with the track. Furthermore, the long ties on which such guard-rails rest are generally insufficiently bedded in the ballast outside of the rails. The tendency of such a guard-rail is to stop the wheel which strikes it and to twist the truck still further, placing it at a greater angle with the track, and thus tending to increase rather than to diminish the danger of an accident. The Board consider such guard-rails to be worse than useless, and recommend that they be replaced by inside guard-rails without delay. Outside guard-rails of proper length, slightly curved and properly laid, may accomplish their intended purpose, but they are wrong in



THE NEW CANADIAN PACIFIC STATION AT MONTREAL.

BRUCE PRICE, NEW YORK, ARCHITECT.

principle, because they are struck by the wheel at the wrong end of the axle, and if they do their work at all, they do it at great disadvantage.

The objection is sometimes urged against inside guard-rails that a mischievous person may place an obstruction between the guard and track-rails, or that some obstruction may accidentally get there. The Board believe that this argument has no practical weight, and that even if a truck were derailed in this manner it would, by virtue of the guard-rail, pass safely across the bridge. A person who desires to wreck a train can find abundant means of doing it more effectual than this. Further objections are sometimes pleaded that the use of the snow-plow is rendered difficult, or that a hanging chain may catch on the point of the guard-rail. These also appear to the Board to have little weight. The points may be protected as already explained, and the use of the snow-plow is no more interfered with than at any turnout or crossing. Finally, it is sometimes urged that a truck, if derailed far enough to get on the wrong side of the point, would be still further deviated by the guard-rail.

As long as a train holds together it is very rare for a truck to be off the track more than a few inches or a foot. If the train has parted and a truck is off by as much as one-half of the gauge, the wheels on one side of this truck would be off the ties and a smash-up could hardly be averted, no matter what shape of guard-rail were applied. Certainly the ordinary form of outside guard-rail would do no good. Furthermore, the possibility of such an accident at a bridge may be almost completely removed by extending either the guard-rails or a single guard-rail on curved approaches, as has been suggested.

THE CANADIAN PACIFIC STATION AT MONTREAL.

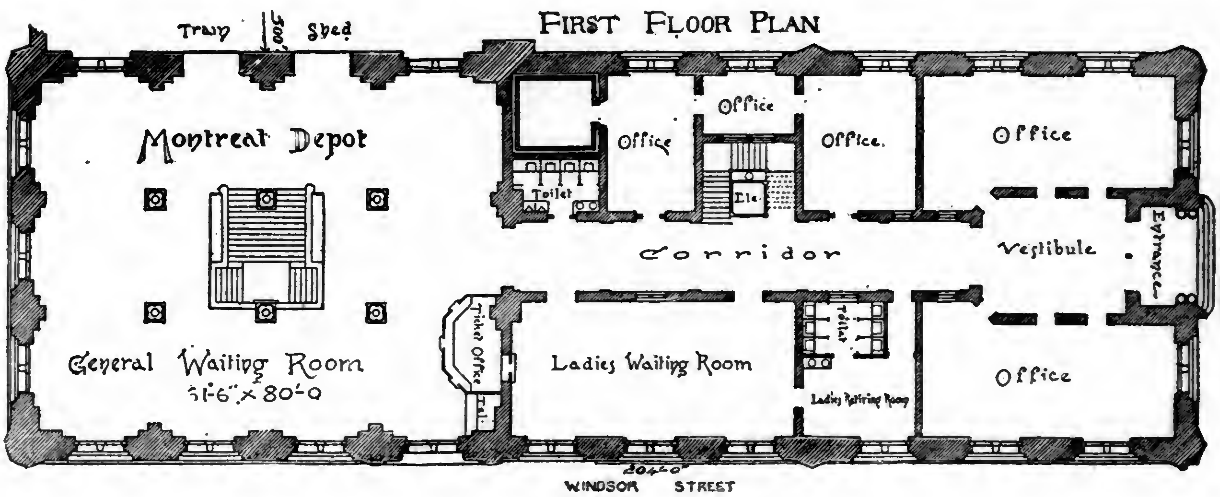
The accompanying illustrations (for which we are indebted to the courtesy of the *Engineering and Building Record*) show a general view and the first-floor plan of the new passenger station of the Canadian Pacific Railroad at Montreal. As will be seen from the engraving, the building stands on rising ground, the basement being a full story at one end and wholly underground at the other. There are four full stories above the basement, besides a finished story in the roof. The general dimensions of the building are 204 ft. front and 70 ft. deep.

The train shed, in the rear of the main building, is 500 ft. long.

The material used in the building is stone, Scotch rubble-face, with rock-face belt courses. The interior finish is in Vancouver cedar. The general waiting-room, on the first floor, is arched over, with granite columns and arches finished in plaster. The floor-beams throughout the building are iron, with fire-proof finish.

The accompanying plan shows the arrangement of the first floor. The upper floors are used for the offices of the company.

The architect, Mr. Bruce Price, of New York, has designed a building very pleasing in its general effect and apparently well suited for its purpose. The cost of the new station is about $250,000 in all.



THE CANADIAN PACIFIC. STATION AT MONTREAL.

The Separation of the Passage and Emergency Powers for Warships.

[Paper read by Chief-Engineer N. B. Clark, U. S. N., before the United States Naval Institute.]

A MODERN warship should have sufficient motive power to drive her at least 20 knots per hour in an emergency, such as chasing an enemy, or escaping from a superior force.

Her engines should also be designed so that while steaming from port to port they may function with the utmost economy at one-half that speed, at which she would consume, under ordinary circumstances, as much as 95 per cent. of her fuel. As the sea endurance of the vessel depends so largely upon her economy of fuel at a low speed, the importance of the subject to a navy with few coaling stations needs no comment.

As the attainment of 20 knots per hour requires approximately eight times the power necessary to attain a speed of 10 knots, it will be readily understood that the two powers cannot be developed with equal economy in the same cylinders.

Soon after the organization of the Naval Advisory Board, under whose auspices the *Chicago*, *Boston*, *Atlanta* and *Dolphin* were constructed, I submitted to that body the plan herein described, and urged it upon them as the type of motive power for the new ships.

Each vessel was to be fitted with twin screws, with two separate sets of engines on each screw shaft. The after engines were to be of a high grade of expansion proportioned to the development of the passage power, or about one-eighth of the whole power with which, with the utmost economy of fuel, a speed of 10 knots could be attained. The forward engines on each shaft were to be of a lower grade of expansion, in order to secure lightness of structure, and were to be proportioned for the development of the emergency power, which would be but seldom used. The screw shaft between the two sets of engines was to be fitted with a clutch coupling, whereby the emergency power engine could be readily connected, or disconnected, as occasion required.

An alternative plan submitted was to connect both sets of engines to a counter-shaft, and gear them to the screw shaft with friction gearing. The latter plan presented the advantage of not transmitting the emergency power through the passage-power cranks, and permitted any one of the four engines to be used for propelling the ship, in event of casualty to the others. Under ordinary circumstances the ship while cruising would be driven by her passage-power machinery, thereby avoiding the loss incident to the development of a small power in a large engine.

I also proposed to the Board that two different types of boiler be fitted in each ship. Steam for the passage power was to be generated in boilers of the ordinary durable cylindrical type ; while the steam for the emergency power, which would be but seldom used, was to be generated in the far lighter, but less durable locomotive, or Herreshoff type.

By this means a great saving in the weight of machinery could have been attained—sufficient, in fact, to have fitted the vessels with invulnerable deflective V-shields which would have completely protected the men working the guns, as well as the ammunition in its passage to the guns.

The British Government has adopted the plan of separate boilers in their new ships, and, according to Mr. F. C. Marshall, the armor-clad *Sardegna*, now building by the Italian Government, is to have the same principle applied to her engines, each screw shaft being fitted with two sets of engines, with a clutch coupling between them.

Railroad Safety Appliances in Michigan.

THE report of Hon. John T. Rich, Railroad Commissioner of Michigan, for 1887 contains some interesting statements in relation to the provisions made by law in that State to prevent accidents on railroads. Some extracts are given below :

RAILROAD GRADE CROSSINGS.

The total number of railroad crossings is now reported at 230, which is an increase of 27 over last year. Of these 21 are either over or under, and the remainder, 209, are at grade. This report signifies that there are 55 points within the limits of this State where, with two exceptions, all trains should be brought to a full stop when approaching the same. This requirement has been incorporated into our laws in the interest of the public safety and for the protection of railroad employés and the property entrusted to their charge as well. Generally, I believe, the law is obeyed, but sometimes it is otherwise, and at all times its observance involves delay and great wear and tear of cars and fixtures. To avoid the necessity of making such stops, without prejudice to the safety of the trains and the people upon them, has engaged the attention of inventors and resulted in the perfecting of a device which seems to answer the required conditions and is rapidly becoming an important appliance for the protection of railroad crossings ; it is known as the "Interlocking and Derailing Switch." . . . . .

The advantages gained by the interlocking switch are the nearly or quite absolute protection against crossing collisions, the saving of time in stopping trains, and power and fuel to start, and the general wear and tear to track and rolling stock in stopping and starting. The expense of interlocking and derailing switches has been so large in the past, that railroads have been reluctant to adopt them, but the expense is now materially reduced, and their voluntary adoption by the railroad companies will be much more frequent than in the past. The first interlocking switch used in this State was put in at the crossing of the Grand Rapids & Indiana and the Air Line Division of the Michigan Central at Wasepi, in 1884 ; one at the crossing of the Mineral Range and the Hancock & Calumet, near Calumet, in 1885 ; one at the crossing of the Detroit & Bay City and the Flint & Pere Marquette branch at Saginaw, in 1886. All of these have proven satisfactory in their operation, and no accidents have occurred at any of them. There has never been but one derailment at these switches that has come to the knowledge of this office, since they have been in use. During the present season there have been put in voluntarily by the railroad companies a full interlocker at the crossing of the Michigan Central and the Chicago & Grand Trunk at Nichols, and a second-class interlocker at the crossing of the Chicago & West Michigan and the Toledo & South Haven at Hartford. And there are now in process of erection, also by the voluntary action of the railroad companies, an interlocker at Lansing at the crossing of the Michigan Central and the Lake Shore & Michigan Southern tracks, across the Chicago & Grand Trunk. It is also understood that the Michigan Central and the Grand Rapids & Indiana contemplate putting in one at their crossing at Kalamazoo in the near future.

By the provisions of act No. 236 of the session laws of 1887, the Crossing Board, consisting of the Commissioner of Railroads, the Attorney-General, and the Secretary of State, are required to approve of all maps of proposed new railroads, and if such route cross the track of any other railroad, to determine whether such crossing shall be at grade or otherwise, and if at grade what safeguards shall be provided against accidents. Under this provision of law the Board have required interlockers to be put in at 11 different points, subject to the approval of the Commissioner of Railroads, and provision will be made in every case for the safety of trains which may be derailed through failure of the men in charge to stop in obedience to the danger signal.

HIGHWAY GRADE CROSSINGS.

The number of these exposed points is rapidly increasing and is now reported at 5,965, or something more than an average of one to each mile of road. Of these 227 are protected by gates or flags, and 177 are either over or under the tracks they intersect. Of those crossing above the tracks, 77 are reported as being of the prescribed height of 18 ft. above the rails, the residue, 21, being less. At these latter the safety signals required by law have, I believe, in every case been provided, and have proved efficient devices for the prevention of accidents to brakemen upon the roofs of the cars. There have been but three accidents reported from overhead obstructions during the year, one person having been killed and two injured. Investigation in each of these cases revealed the fact that the signals were in place, but either failed to notify, or the unfortunate trainmen failed to heed their friendly warning.

Accidents at street and highway crossings are of too common occurrence, and frequently with fatal results. Eight persons were killed and 14 injured at such crossings during the year. There are now a large number of men employed as flagmen and gate-keepers at this class of crossings. When flagmen only are employed there have been some very serious accidents ; in some instances the men being temporarily absent from their posts, and people not seeing the flagman, concluding everything was all right, have been struck by the train. In other cases the flagman has been unable to control people and they have been injured. Where gates are used there has been less trouble, but even then, where there are several tracks, teams have been allowed to pass upon the crossing, and before reaching the gate at the further side it has been closed so as to prevent their escape from accident either through fright of their teams or by being struck by a passing train.

There are now on trial automatic electric bells which are rung by the approaching train. They have been only a partial success, but with some improvements they have much to recommend them. If they are properly constructed their action is not dependent on any one's care or presence, they act at all hours of the day and night. Their warning is timely, and the expense of maintenance is much less than to employ a flagman, with or without a gate, or to build a bridge. But there are places where the bell could not be made to answer the purpose. Where the view at the crossing is unobstructed, it is probably safer for people to rely upon their own precautions, rather than to depend on any device for warning them of danger, for none of them are infallible.

AUTOMATIC COUPLERS.

The Legislature of 1885 passed an act requiring all railroad companies to use some form of automatic or safety coupler at each end of all freight cars which they might buy or lease, and upon all old cars sent to the shops for repairs. The same act required the Commissioner of Railroads to select "two or more different patterns of automatic or safety couplers which will couple with each other and with the link-and-pin coupler now generally in use, from which patterns said railroad companies may select couplers for use on cars," as required by said act. Under the provisions of this act, my predecessor selected couplers of seven different patterns, from all of which more or less have been put on freight cars for use in this State.

After something more than a year's experience with them, the result has not been the most desirable. There has been no considerable diminution in the number of coupling accidents, and we are, if possible, no nearer to uniformity than before. Railroad managers have not, apparently, taken the active interest in the subject which might be expected, and the law has not been very strictly obeyed. Even if it was, so far as the cars owned and controlled by railroad companies wholly or partly within this State are concerned, the number of foreign cars used, over which the State has no control, is so great that the same difficulty would remain. An attempt to prevent the running of cars of other States without complying with the State law would be of doubtful expediency, for if enforced it would simply result in causing such cars to be sent by other lines, making a serious loss to the railroad companies of this State, and depriving many of our citizens of their present employment. Then there is no disputing the fact that the men for whose safety and protection the Legislature required the adoption of the automatic or safety couplers (the brakemen) are not satisfied with anything now in use in this State. All the couplers selected by the Commissioner of Railroads were supposed to couple with each other automatically, or at least without the necessity of going between the cars to make the coupling, and also with the ordinary link-and-pin coupler by placing the link in the old drawhead. Repeated observation has shown that very few couplings are made except by going between the cars. It is the universal practice in coupling an ordinary coupler with an automatic, to place the link in the latter and guide it into the former with the hand. To ask why this is done brings the uniform reply that "the automatic is no good;" that "they don't work half the time, and that they had rather do it the old way and be sure." The coupler having the most friends among brakemen is one presenting a concave space on the lateral sections of the face of the drawhead for the protection of the hand while guiding the link to make the coupling. In other respects it is simply the ordinary link-and-pin drawbar. With one exception the couplers selected for use in this State are what are known as link couplers. The reasons for this undoubtedly were that until very recently most railroad men have considered the link necessary to a freight coupler, and as no device was adopted without the approval of one or more railroad managers, it is to be supposed that the selections were made in accordance with the ideas of practical railroad men. The law also required all the couplers to couple with the link-and-pin coupler in general use, and automatic link couplers generally do this more successfully than those which dispense with the link.

The Legislature of 1887 amended the act of 1885, so that the railroad companies might use any coupler which came up to the standard fixed by the law of 1885, and was approved by the Commissioner of Railroads. Under this act no new couplers have been added to the list for use in this State, and only one application has been made by any railroad company for the approval of any coupler. That was made by the Grand Rapids & Indiana Railroad Company for the approval of the Janney, which is a vertical hook coupler, and makes a close coupling, similar to those used on passenger cars. Approval was withheld, because it could not be coupled with the ordinary link-and-pin coupler without going between the cars, and from the shape of the end of the drawhead seemed more than usually dangerous to couple by hand, hence the approval of it for use was deemed to be in violation of the spirit if not of the letter of the law. No objection appears to its use when it couples with its kind.

Since this action the Master Car-Builders' Association of the United States has, by a vote of more than two-thirds of its members, adopted couplers of the Janney type, and those that will couple with them, as the standard for uniform use throughout the United States, and are making a determined effort to have it generally adopted. The Janney has been used more or less on the Pennsylvania Railroad for some years, and is met with frequently in this State on the cars of that company, especially on the Grand Rapids & Indiana Railroad. It is also used extensively by the companies carrying dressed meats on their refrigerator cars, and running more or less on all our roads, and especially on the Michigan Central and the Chicago & Grand Trunk. If adopted for general use it does away with the link and its consequent loose coupling, and substitutes the close coupling, heretofore supposed to be adapted only to use on passenger cars. In view of these facts it is a question whether approval for its use by the railroad companies of this State should be longer withheld by this department.

POWER BRAKES.

The number of trains which it has become necessary to run on a single track, and the additional weight of trains caused by the increase in both number and weight of cars and their lading, the numerous railroad crossings at which trains must stop, and the demand for the rapid transportation of freight made by the dressed-meat transportation companies, and others who have perishable freight to move, are causing railroad officials to look for some more efficient means of checking the speed of trains than the hand brake. Some of the refrigerator lines have equipped their cars with the air-brake, but if drawn by engines lacking the proper appliances for operating such brakes, they are in the same condition as though they had no air-brake attachment. When the economy in time, the lessened exposure of brakemen by not being required to go upon the roofs of cars to apply brakes, and the greatly increased power for the prevention of collisions are considered, it would seem that freight as well as passenger trains should be required by law to be fully equipped with some kind of power brake. Another reason why this should be done is, that there are many trains run, composed of both passenger and freight cars, which seem to be necessary to save unnecessary expense to railroad companies and for the accommodation of the people. Yet at present they are entirely dependent upon the hand brake unless the engine is equipped with power brakes, which is not the rule at present. This class of trains have day cars, and in some instances sleeping-cars are attached, and are provided with no efficient means of checking the speed of the train in case of an accident. The law provides that no baggage or freight car shall be placed in the rear of a passenger car.

Another section of the law provides that no regular passenger train shall be run without an air-brake or some equally effective device for checking the speed of the train, which may be applied to each passenger car composing the train. If this class of trains are regular passenger trains, then they must have the air-brakes, and when they run regularly and are advertised as passenger trains they may be reasonably considered as such, even though they do take freight as well. There should certainly be some means provided for this class of trains, and the requiring all trains of every description to be equipped with power brakes would be almost the only effective means to accomplish it.

Trials recently made at Chicago, St. Louis, and other places conclusively demonstrate the practicability and advantage of having freight trains fully equipped with some form of power brake.

CAR HEATERS.

By act No. 118 of the session laws of 1887, it is provided, "That on and after the first day of November, 1888, every railroad company owning or operating any railroad wholly or partially within this State shall make some effective provision against the burning of cars in which passengers

are carried, in some one of the following or equally effective methods: By generating the heat for warming the cars outside and independent of said cars, or by enclosing the heater in a closet or room made of boiler-iron, or some other material which will afford equal protection against the car taking fire, or some device by which the fire will be effectively and quickly extinguished in case the car is overturned."

The intent is evidently to avoid heating cars with what has come to be known as the "deadly car stove." Various devices will be tried during the coming winter, and there is no doubt that the experience gained during the winter of 1887–88 will go far toward determining the principle upon which cars will be heated in the future. Some plan of taking steam from the locomotive seems to have more friends at the present time than any other.

LOCOMOTIVE BOILER EXPLOSIONS ON BRITISH RAILROADS.

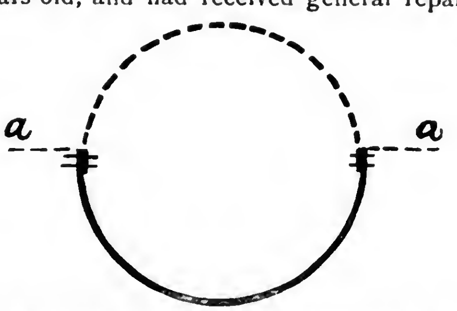
(*Continued from page 27.*)

WE continue below the summary of the Inspectors' reports to the British Board of Trade on accidents resulting from the failure of locomotive boilers.

INSPECTORS' REPORTS.

January 8, 1872, the boiler of a locomotive drawing a freight train on the Glasgow & Southwestern line exploded near Fochabers. The train had started from the station a minute before, and at the time of the explosion was running down grade, using very little steam. The crown-sheet of the outer shell of the fire-box, a plate of $\frac{9}{16}$-in. iron about 6 ft. 8 in. by 5 ft. 3 in., was completely torn off and separated into three portions, two large and one small. A large triangular piece of one of the side-sheets was also torn out, and the other side-sheet was doubled down over the frame. A brakeman, who was on the engine, was killed, the engineer and fireman badly hurt. The engine had 17×22-in. cylinders, four-coupled drivers 5 ft. diameter, and leading wheels 3½ ft. It was nine years old; the boiler had been four times repaired, the last time only two months before the explosion, when 20 new stay-bolts were put in. At that time the safety-valves were tested and fixed at 120 lbs., but no test was made of the boiler. A careful examination of the boiler showed no indications of corrosion serious enough to cause the explosion. The top row of stay-bolts was somewhat defective. The iron plates were generally good, except that some indications of crystalline fracture were found in the throat-sheet. The Inspector believes that this weakness and the defective stay-bolts caused the explosion; he thinks that the boiler should have been subjected to a hydraulic test when repaired.

February 5, 1872, the boiler of the engine of a coal train on the Whitehaven, Cleator & Egremont road exploded at Moor Row station. The engineer was killed. The engine had six wheels coupled and a saddle-tank. It was 10 years old, and had received general repairs about



four months before, but the boiler was not then examined. A new set of tubes had been put in 2½ years before, and a careful examination had then showed no serious defects. The barrel of this boiler was 50 in. diameter and about 13 ft. long; it was made with two plates in its girth, the joints of those next the fire-box being opposite each other in a horizontal plane passing through the axis of the boiler; the joints overlapped, the lower over the upper plate, about 3½ in., and were double riveted, the rivets having 2½ in. pitch. The vertical joints were single riveted. The plates were of $\frac{7}{16}$-in. iron and had been very little reduced by wear. The accompanying sketch shows a section of the barrel of the boiler, the dotted portion showing the plate which was blown off. Examination showed that the rupture took place in a straight line along the joint, and it appeared that the plate was deeply corroded along this line, the sheet at some points being only from $\frac{1}{16}$ to $\frac{1}{8}$ in. thick. There was also a good deal of pitting at other points. The reason of the explosion was therefore very evident; the only wonder was, in fact, that the boiler held together as long as it did. The Inspector believes that proper inspection would have shown the weakness of the boiler.

September 16, 1872, the boiler of a locomotive on the Dublin, Wicklow & Wexford road exploded while the engine was standing at Bray station. It was a six-wheel tank engine, with one pair of drivers 5½ ft. diameter, leading and trailing wheels 3½ ft. The boiler was 48 in. diameter of barrel and 10. ft. long. It was of $\frac{3}{8}$-in. iron, single riveted, with ¾-in. rivets pitched 1¾ in. The barrel was torn completely away from both smoke-box and fire-box, and separated into no less than 21 pieces, which were thrown off in all directions. Some evidences of corrosion were found, the bottom of the barrel being reduced at some points to about $\frac{3}{16}$ in. The man-hole casting and plate the Inspector thought too weak. The evident cause of the explosion, however, was over-pressure, and there was evidence that the safety-valve had been wedged down by the engine-driver, who was killed.

August 22, 1873, the boiler of the locomotive of a goods train on the South Devon Railway exploded just after the train had stopped at Brent station. The engine was a tank engine with 17×24-in. cylinders and six 57-in. wheels, all coupled. The boiler barrel was 10 ft. 2 in. long and 53 in. diameter, of ½-in. iron plates, single riveted with ¾-in. rivets spaced 1⅞ in. apart. The engine was provided with one pump and one injector. The steam dome and tank were blown clear away; the center ring of the boiler and part of the ring next to the fire-box opened at the top, and the plates were folded back at each side, leaving the tubes bare; they were very slightly injured. The front plate of the fire-box was slightly bulged forward at each side near the top. The engineer, fireman, and a boy standing by the track were scalded. The evidence indicated that the injector was out of order, that the pump had not been put on, and that water had been allowed to get low in the boiler. When the engine stopped at Brent the injector began to work again, and the explosion was caused by the sudden and rapid generation of steam when the water began to flow into the boiler.

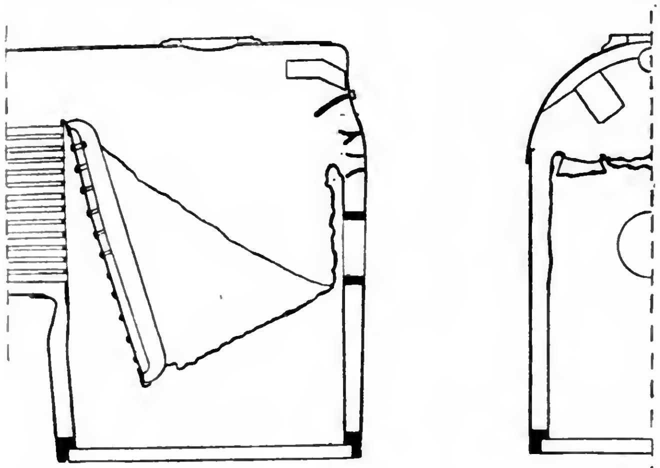
August 25, 1873, the boiler of a goods engine on the Taff Vale road exploded at Cardiff Dock, while the engine was waiting to go out with a train. The whole barrel was blown away by the explosion; one piece of plate was turned over and remained hanging to one side of the fire-box shell and another plate remained hanging to the smoke-box. The rest of the barrel was torn into six pieces, which were thrown off in different directions. The working parts of the engine were badly damaged. The engine had 16×24-in. cylinders and six 56-in. wheels, all coupled. The boiler was 50 in. diameter and 10½ ft. length of barrel, of $\frac{7}{16}$-in. iron plates, lap-jointed, with ¾-in. rivets, spaced diagonally, 2¼ and 1⅝ in. apart. It was nine years old. About two years before the explosion new tubes, new tube plates, and three new plates in the barrel were put in, two of the latter forming the ring next the smoke-box, the third the lower part of the middle ring. The under plate next the fire-box was pitted, but was thought good enough to remain, but a patch or liner-plate 21 in. by 9 in. was riveted on it to stop further pitting. The Inspector says in this case:

"The method adopted in putting on the patch or liner-plate reduced the strength of the bottom plate of the boiler, which was already defective, about one-half, and there can be no doubt that it exploded from the weakness created by this work.

"It is always a mistake to patch locomotive boilers. The expense, in the present case, of the three new plates

and the patch was probably greater than if the boiler had been renewed."

May 22, 1874, the boiler of a goods engine on the Great Western Railway exploded near Aberdare. The engine was used to work a short coal branch, and at the time of the explosion had been running backward down a very heavy grade, but had stopped on account of the train breaking in two. Both engineer and fireman were killed; two other employés were hurt. The engine was thrown back along the track over 200 ft., and then went off on one side of the rails. The engine in this case had 16×24-in. cylinders and six 54-in. coupled wheels. The boiler was 11 ft. long and 48 in. diameter of barrel; the fire-box was 5 ft. 2 in. long and 4 ft. 1¼ in. wide outside; 4 ft. 6¾ in. long, 3 ft. 6¼ in. wide, and 5 ft. 2 in. high inside. There were 235 tubes 1⅝ in. diameter and 11 ft. 5 in. long. The outer fire-box shell was of $\frac{7}{16}$-in. iron, the inner shell of $\frac{7}{16}$-in. copper. As will be seen from the accompanying sketch, taken after the explosion, its force was entirely in

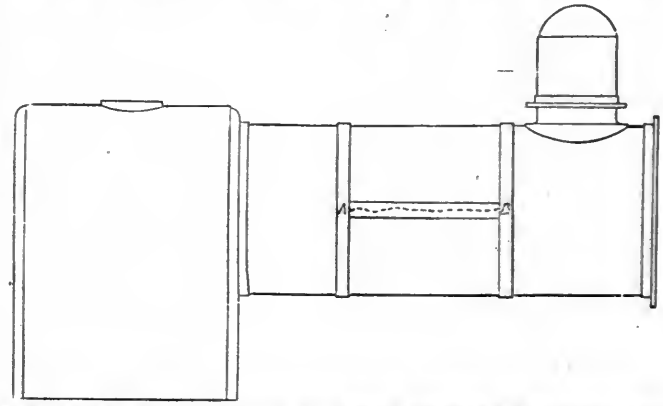


the fire-box. The crown-sheet was torn from the side-sheets and forced down against the tube-sheet, the roof-stays or crown-bars going with it. The sling-stays by which the roof-stays were held to the outer crown-sheet were all broken. The outer iron shell of the fire-box was bulged out of shape, as shown, but was not seriously damaged. None of the crown-bars were broken, although some of them were bent. The fracture took place along the edges of the copper crown-sheet. The back-plate of the fire-box was also torn out of shape. No evidences of serious corrosion or weakening of the plates could be discovered. It appeared that the steam-gauge had been taken off for repairs, and that the engine was running at the time without a gauge. The Inspector believes that the explosion was caused probably by high pressure and low water, and finds much fault with the absence of the steam-gauge.

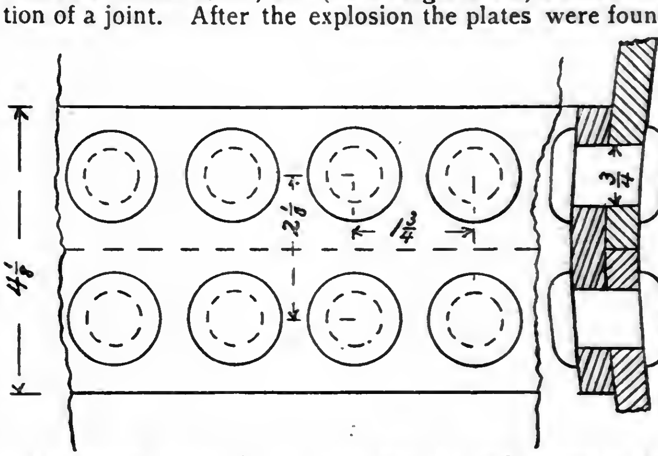
November 28, 1874, the boiler of a shifting engine on the Lancashire & Yorkshire road exploded in the yard at Leeds. The engine was a tank engine with a boiler 48 in. diameter of barrel and 11 ft. long. The explosion took place in the first ring next the smoke-box, and the plates were generally torn apart along the lines of rivets. The boiler had not been overhauled for six years, but some six months before, when other repairs had been made to the engine, it had been tested up to 170 lbs.; the usual working pressure was 120 lbs. Examination showed much corrosion, the barrel plates having been reduced in places from $\frac{7}{16}$ to less than ½ in. There was no appearance of undue heating or low water, and the explosion was probably due to the weakness caused by the corrosion. The Inspector censured the long time allowed to pass without a full examination of the boiler.

February 26, 1875, the boiler of a shifting engine on the Northeastern road exploded at Middlesboro, injuring three men. The rear end of the engine was lifted up and thrown off the rails. The engine was 18 years old, but the boiler had been repaired and a new sheet put in the fire-box three years before. In this case a piece of the copper side-sheet of the fire-box about 4½ by 2 ft. was torn out, and he fire-box was much distorted in shape. This was a case of corrosion and general weakening; the copper plate had been worn down from ½ in. to less than ¼ in., and of 44 stay-bolts in the broken piece of the sheet only 12 retained their hold. There were in all 80 stay-bolts in the side-sheet, and of these only 18 remained good and kept their hold on the sheet.

June 26, 1875, the boiler of the engine of a goods train on the Manchester, Sheffield & Lincolnshire line exploded at Dodworth, injuring two persons. The barrel of the boiler was almost completely broken up, the pieces being thrown in different directions, one or two of them to a distance of 650 ft. The engine had 18×24-in. cylinders and six 5-ft. wheels, all coupled. The boiler was 51 in. diameter of barrel and 10½ ft. long; it was 15 years old.



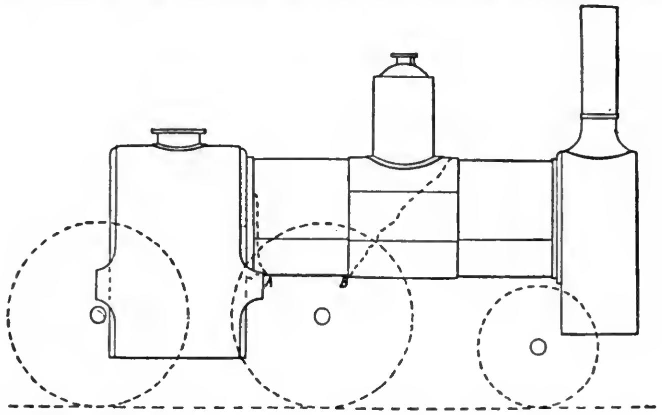
It had been inspected two months before the explosion and found to be in good condition. It was of ½-in. iron plates with butt joints, the edges of the plates being planed and the joint covered on the outside by a welt or strip of ½-in. plate, 4 in. wide. There were two rows of rivets ¾ in. diameter spaced 1¾ in. The caulking was done inside, on the planed joints. The accompanying sketches are a general view of the boiler, and (on a larger scale) a short section of a joint. After the explosion the plates were found



to be generally sound, but there was a crack in one of the cover-strips about 34 in. long and extending nearly half way through the strip. The explosion is believed to have started in this cracked strip, on the line *A B* in the diagram. The Inspector thinks that there is no way of ascertaining the existence of a defect of this kind, and believes that it would be of little use to make the strips thicker. He says: "The apparent lesson to be learned from this explosion is in favor of giving up the use of butt joints covered with strips or welts in the construction of the barrels of boilers."

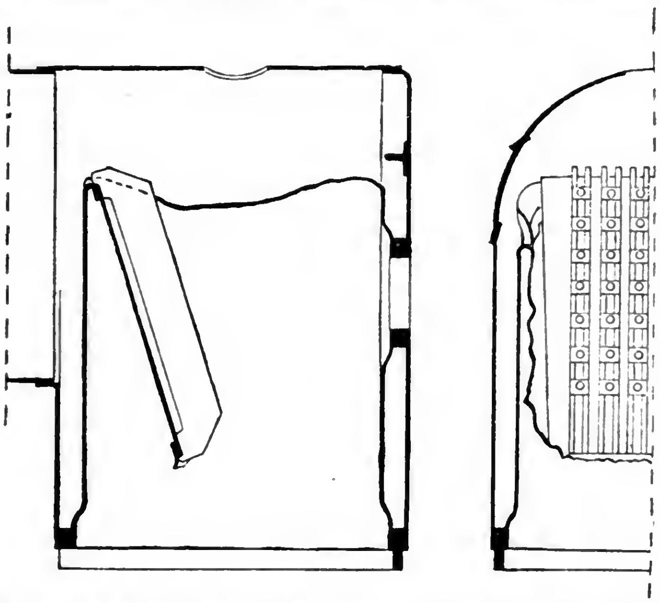
July 23, 1875, the boiler of the engine of a passenger train on the Northeastern line exploded while the train was standing at Holbeck station, injuring the engineer, the fireman, and two men who were standing near. The rear end of the barrel of the boiler was torn to pieces, and the engine was pretty well demolished. Pieces of the boiler were thrown in all directions, one landing some 600 ft. away. The engine had 15×22-in. cylinders, four coupled wheels 6 ft. diameter, and leading wheels 4 ft. diameter. The boiler was 46 in. diameter of barrel and 10½ ft. long; it was of $\frac{7}{16}$-in. iron plates and was worked usually at 120 lbs. pressure. The engine was 22 years old, and had received general repairs two years before.

The accompanying sketch is a general view of the boiler, the dotted lines showing approximately the lines of fracture. The fracture also extended along the bottom of the



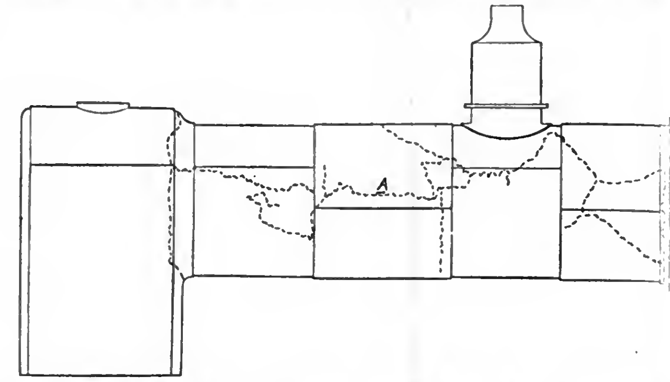
barrel, on the line *A B*. Examination showed that in several places the plates were laminated, the inner layer being about $\frac{1}{8}$ in. thick, and that this inner layer was in several places corroded or eaten through, the water getting between the two layers so that the corrosion had extended almost through the plate.

March 28, 1876, the boiler of the engine of a construction train on the Glasgow & Southwestern line exploded near Kilmarnock, while the engine was running. The crown-sheet of the fire-box gave way, and the force of the explosion lifted the engine up and threw it over on a car, which was broken to pieces. The engineer, fireman, and guard were killed. The accompanying sketch gives a longitudinal and half cross-section of the fire-box, showing the condition in which it was left after the explosion.

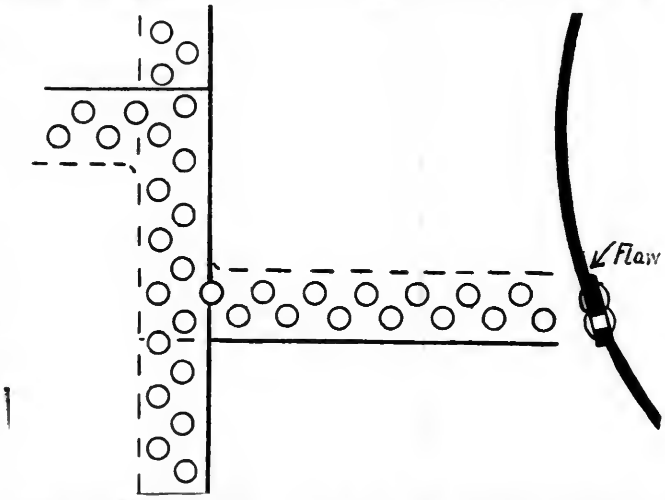


From the examination the Inspector concluded that the boiler was in good condition, and that the explosion must be attributed to low water, the crown-sheet having been overheated, and then unable to resist the pressure from the rapid generation of steam when water was pumped in. He also thought that the boiler was defective in having no vertical stays to connect the crown-bars with the outer shell; such stays might have prevented the explosion. The engine in this case had 16×22-in. cylinders, four coupled wheels 60 in. diameter and 42-in. leading wheels. It was 18 years old.

March 28, 1877, the boiler of the engine of a goods train on the Northeastern line exploded while the engine was taking water at Alne. The upper part of the barrel was completely destroyed, and eight pieces (the largest about 5 by 3 ft.) were blown off in various directions, one falling 540 ft. away. The boiler was 12 years old, of $\frac{7}{16}$-in. iron, and had been repaired three years before. The accompanying sketches show the boiler, the dotted lines showing the lines of fracture, and (on a larger scale) part of a seam, showing the method of riveting. On the upper edge of one of the plates (at about the point marked *A*) there was found a flaw, where the plate had been eaten through



until only about $\frac{1}{8}$ in. of sound metal was left. This flaw, owing to the collection of sediment and incrustation on the edge of the plate, could not have been seen under any



ordinary examination. This flaw undoubtedly caused the explosion. The Inspector says: "The practice of arranging the plates of boilers so that the lower pass inside the upper, by which rest-joints are introduced, in which deposits take place, preventing the discovery of flaws, does not seem to be judicious."

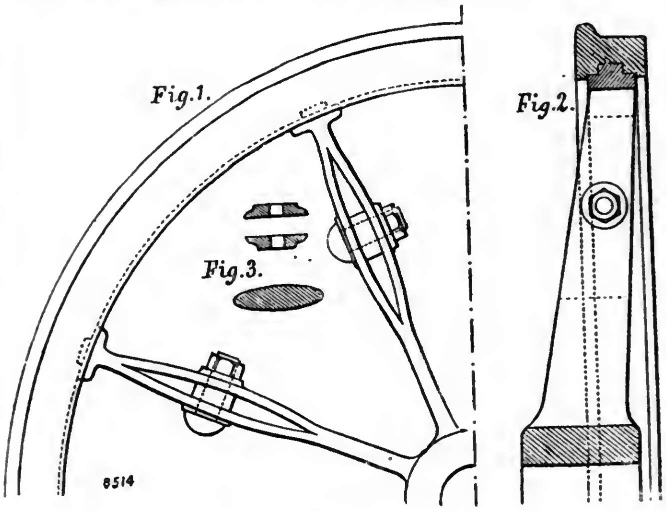
September 11, 1877, the engine of a passenger train on the Great Western road exploded its boiler at Oakengates, killing the engineer and injuring the fireman. The explosion is thus described by the Inspector: "The midfeather is a partition across the lower part of the fire-box, which contains water. Its object is to give more heating surface, promote the circulation of water, and assist in consuming smoke. They are not generally used in narrow-gauge engines. In the present case the midfeather was of $\frac{1}{2}$-in. copper plate, like the rest of the fire-box, and was stayed with solid 1-in. copper stays and copper tubes, which were screwed into the plates, the ends being hammered down to assist in holding them fast. The plate at the front end of the midfeather had been reduced by wear to a thickness of a little over $\frac{1}{8}$ in., the thinnest part being about the level of the top of the fire. The stays were pulled through the plates by the pressure of steam and water inside the midfeather, and the water rushed through the holes into the fire. An explosion of steam occurred, which broke down the ashpan and fire-bars, rushed through the fire-door, and knocked the engineman and fireman into the tender. . . . The accident was caused by the plates being so much reduced in thickness that they could not hold the stays."

The reports of all the companies for the year 1877 show that during that year there were four accidents due to failure of boilers or parts of boilers, by which two persons were killed and two injured. Two of these accidents were reported on; the other two were slight, caused by failure of tubes.

(TO BE CONTINUED.)

Interchangeable Steel Wheel for Street Cars.

THE accompanying engraving, from the London *Engineering*, shows a new form of wheel for street-cars, in which the tire can be removed from the center and replaced, when worn, with very slight trouble, and without taking the wheel off the axle. The center of the wheel is cast in one piece of mild Swedish crucible steel, and each spoke has an oval-shaped opening running lengthwise near its outer end. When the wheel is to be put together the center is placed inside the tire, which is rolled of cast-



STEEL TRAMWAY WHEEL.

MADE BY HANSELL & CO., SHEFFIELD, ENGLAND.

steel, and each spoke is lengthened until it gets a firm bearing, by drawing together the two sides of the oval mentioned above. This is effected by steel bolts and nuts, the amount of compression being regulated by a broad spring washer placed between the two members of the spoke. In order to make the connection between the arms and the tire more secure, the ends of several of the arms are circular for a distance of about ½ in., and fit into corresponding recesses formed internally in the tire. The center can be removed and fitted with new tires as often as required.

Electric Motors—The Wrong Way and the Right Way.

(From the *Electrical Engineer*.)

A WELL-KNOWN electrician of our acquaintance had occasion a short time since to consult a manufacturer of locomotives, whose street-railroad motors have attained a national reputation for economy and general efficiency, with reference to the construction of an electric motor. The manufacturer at once exclaimed that it was useless for him to estimate on electric machinery, as he had found by experience that electrical people would not pay for the quality of workmanship that was required for proper locomotive running gear. What they wanted, he said, was a cheaper class of work, such, for example, as that used in a rather poor grade of agricultural implements.

This remark might well furnish a text for a very instructive sermon. If a locomotive is to haul a certain load over a given track, it is certainly very poor economy to use less perfect running gear for an electric than for a steam motor. Yet many electric motors which we have seen are eloquent witnesses to the truth of the remarks of the locomotive builder. And as if this were not enough, we have noted a certain disposition on the part of some electric-railroad people to undertake what may be called feats of sensational engineering, such as running over imperfect tracks, and up and down impracticable gradients, and the like. There is no reason whatever to suppose that an electrically driven locomotive can run with safety where a steam driven one cannot, yet it is quite apparent that many people who ought to know better are being carried away with the delusion that any railroad problem that presents peculiar difficulty can be solved at once by the application of electricity, just as we heard it gravely argued, during the prevalence of the narrow-gauge craze some years ago, that a locomotive of 3-ft. gauge could ascend a steeper incline, other things being equal, than one of 4 ft. 8½-in. gauge. We hear, for instance, of one line on which an attempt is to be made to work grades of over 700 ft. per mile with electric locomotives, for passenger service. Unless special precautions are taken, as, for example, on the Mt. Washington or Mt. Cenis inclines, to undertake such a feat is to invite disaster.

The legitimate field which is now open to the electrically driven street-car is surely extensive enough without encroaching upon territory which legitimately belongs to the cable system. It is not good policy or good sense to make use of electric power in cases where it must compete, under unfavorable conditions, with directly applied steam power under favorable conditions. But this is precisely what is done, in effect, when we put inferior workmanship into electric motors, or when we attempt to use them in situations where an inclined cable system is obviously a much more safe and economical one.

COMPOUND LOCOMOTIVE FOR FREIGHT SERVICE.

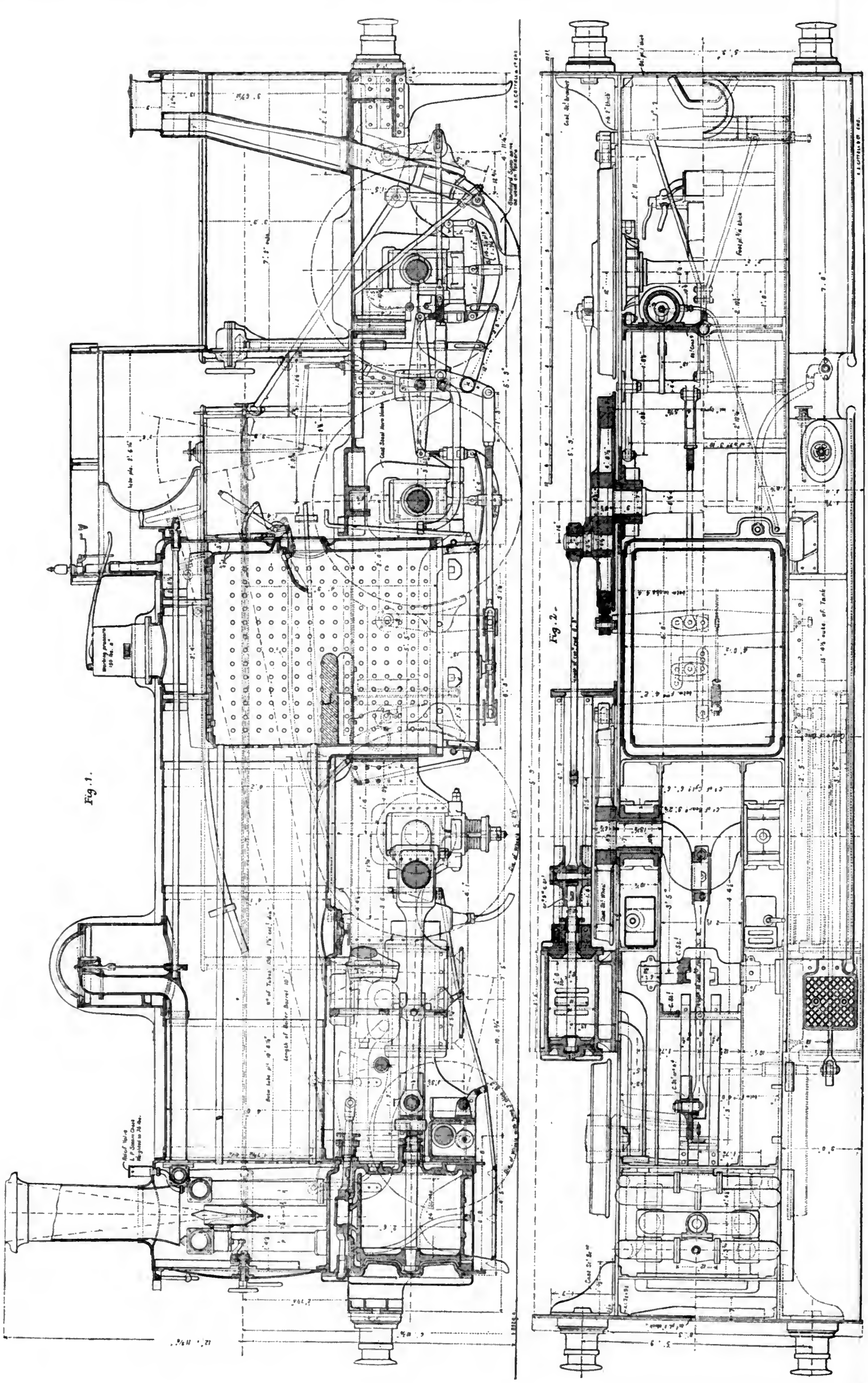
THE accompanying engravings show a longitudinal section and plan of a compound locomotive for freight service built at the shops of the London & Northwestern Railway at Crewe, England, from the designs of Mr. F. W. Webb, Chief Mechanical Engineer of that road. A perspective view of a locomotive of this class was published in the JOURNAL for August, 1887, page 363. The description of this engine, taken, with the engravings, from the London *Engineering*, is as follows :

This engine is of a type which has been designed for working the express goods traffic on the main lines of the London & Northwestern Railway. It is similar in principle to the passenger engine exhibited by Mr. Webb at the Inventions Exhibition and at Liverpool, the disposition and size of the high and low-pressure cylinders being identical—viz., two high-pressure cylinders 14 in. in diameter with 24-in. stroke, fixed outside the frames, the connecting-rods working back on to the pair of wheels immediately behind the fire-box, and one low-pressure cylinder, 30 in. in diameter with 24-in. stroke, fixed between the frames at the front end of the engine, and with its piston working on to a single-throw crank in the pair of wheels immediately in front of the fire-box.

The engine is carried on four pairs of wheels, the leading pair being 3 ft. 9 in. in diameter and fitted with Mr. Webb's arrangement of radial axle-box with central controlling spring ; the other wheels are all 5 ft. 2½ in. in diameter. To obtain the adhesion equivalent to a six-wheel coupled engine, the high-pressure and hind pairs of wheels are connected by short coupling-rods, so that there are two pairs of wheels connected to the high-pressure engine and one pair to the low-pressure engine, making three pairs of driving wheels in all.

The details have been worked out in a similar manner to those for the passenger engines, and the journals kept as long as possible ; compensating beams connecting the bearing springs have been placed between the coupled wheels. Among special features it may be noted that the blast nozzle has an annular discharge, the nozzle—itself 5¼ in. in diameter—having within it a double conical plug 2¾ in. in diameter at the largest part, which can be adjusted at the desired height by means of the spindle which carries it.

Similar engines to the one described, only smaller, have been at work for some time on the Antofagasta Railroad, South America, and Mr. Woods, the Engineer of the railroad and President of the Institution of Civil Engineers, reports very favorably as to their working. We may add, too, that up to the end of last half year more than 6,500,000 train-miles had been run with Mr. Webb's compound



COMPOUND LOCOMOTIVE ON WEBB'S SYSTEM, FOR FREIGHT SERVICE.

BUILT AT THE LONDON & NORTHWESTERN RAILWAY SHOPS, CREWE, ENGLAND. F. W. WEBB, CHIEF MECHANICAL ENGINEER.

engines on the London & Northwestern Railway, on which line they are now doing all the heaviest main line work and saving a large amount of double-engine running which was formerly necessary.

The following are the dimensions of the engine illustrated :

CYLINDERS AND MOTION (VALVE MOTION, JOY'S) :

	Ft.	In.
High-pressure cylinders 2		
Diameter	1	2
Stroke	2	0
Length of ports	0	10
Width of steam ports	0	$1\frac{3}{8}$
" exhaust "	0	$2\frac{3}{4}$
Maximum travel of valve	0	$3\frac{1}{2}$
Lap of valves	0	$0\frac{11}{16}$
Lead "	0	$0\frac{3}{16}$
Inside clearance	0	$0\frac{3}{16}$
Distance between centers of cylinders	6	6
Low-pressure cylinder 1		
Diameter	2	6
Stroke	2	0
Length of ports	1	6
Width "	0	2
" exhaust ports	0	$4\frac{3}{4}$
Maximum travel of valve	0	5
Lap of valve	0	1
Lead	0	$0\frac{1}{2}$
Length of high-pressure connecting-rods between centers	8	3
Diameter of crank-pin bearings (high-pressure)	0	4
Length of crank-pin bearings (high-pressure)	0	5
" coupling rod	5	9
" low-pressure connecting-rod between centers	5	8
Diameter of low-pressure crank bearings	0	$7\frac{3}{4}$
Length " " "	0	$5\frac{1}{2}$

FRAMES :

	Ft.	In.
Thickness of main frames (steel)	0	1
" inner " "	0	$0\frac{3}{4}$
Distance between main frames	4	2
" " inner "	2	$1\frac{1}{2}$
Length of engine framing over buffer plates.	31	$0\frac{1}{4}$
Width over footplates	8	2

WHEELS, AXLES, AND SPRINGS :

	Ft.	In.
Diameter of leading wheels, with 3-in. tires	3	9
" low-pressure driving wheels, with 3-in. tires	5	$2\frac{1}{2}$
Diameter of high-pressure driving wheels (coupled), with 3-in. tires	5	$2\frac{1}{2}$
Distance between leading and low-pressure driving wheels	7	6
Distance between low-pressure driving wheels and high-pressure driving wheels	8	3
Distance between high-pressure coupled wheels	5	9
Total wheel base	21	6
Leading axle, diameter at center	0	$5\frac{3}{4}$
" " " bearings	0	$6\frac{1}{4}$
" " " wheel seats	0	$7\frac{1}{2}$
" " length of bearings	0	10
" " centers "	3	$8\frac{1}{2}$
Crank axle, diameter of bearings	0	7
" " " at wheel seats	0	$8\frac{1}{2}$
" " length of bearings	1	$1\frac{1}{2}$
" " centers "	3	$2\frac{1}{2}$
High-pressure driving axle and trailing axle, diameter at center	0	$6\frac{1}{2}$
High-pressure driving axle and trailing axle, diameter at bearings	0	7
High-pressure driving axle and trailing axle, length of bearings	0	9
High-pressure driving axle and trailing axle, centers of bearings	3	10
Leading springs, span	2	8
" " number of plates 16		
" " width	0	$4\frac{1}{2}$
" " thickness	0	$0\frac{3}{8}$
Driving springs, low-pressure. Four spiral springs $3\frac{3}{4}$ in. in diameter, $\frac{9}{16}$ in. square steel coiled R. H., with four internal spiral springs $2\frac{1}{2}$ in. in diameter, $\frac{7}{16}$ in. square steel coiled left hand.		
High-pressure driving and trailing springs, span	2	4
High-pressure driving and trailing springs, number of plates 15		
High-pressure driving and trailing springs, width of plates	0	4
High-pressure driving and trailing springs, thickness—top plate $\frac{7}{16}$ in., the rest $\frac{3}{8}$ in.		

BOILER :

	Ft.	In.
Diameter of barrel outside middle ring	4	1
Length " " "	10	1
" firebox casing	5	5
Extreme depth of firebox casing below center line of barrel	4	$10\frac{7}{8}$
Thickness of barrel plates	0	$0\frac{1}{2}$
" fire-box tube plate (copper)	0	$0\frac{7}{8}$
" smoke-box " (steel)	0	$0\frac{3}{4}$
" other fire-box plates (copper)	0	$0\frac{1}{2}$
Number of tubes (brass) 198		
Diameter outside	0	$1\frac{7}{8}$
Length between tube plates	10	$4\frac{1}{8}$
Diameter of chimney at bottom	1	4
Height of center of barrel above rails	6	$10\frac{3}{4}$

Heating surface :		
	Tubes	1004.25 sq. ft.
	Firebox	94.6 "
	Total....	1098.85 "
Grate area		17.7 "

The ratio of the grate area to the heating surface is 1 : 64.26. The usual working steam pressure is 160 lbs.

The tanks have a capacity of 1,400 gallons, and are provided with a pick-up to take water from track-tanks while the engine is running.

The total weight of the engine empty is $43\frac{1}{2}$ tons.

Bernardo's Method of Electric Welding.

(Dr. R. Ruhlmann in the London *Electrician*.)

WHEN the author first saw Dr. Bernardo's method in use at St. Petersburg he was involuntarily reminded of Columbus and the egg. It has been well known for many years that almost all substances were fusible in the electric arc, and Siemens, Wallner, Cowles, and others have done much work in the direction of electrical welding by this means, with more or less success.

The principal point in which Bernardo differs from his predecessors is that he makes the metal to be welded *itself the negative pole*, the positive being a carbon rod.

The strong reducing action thus brought to bear on the metal keeps it perfectly clean and unoxidized. If the poles are reversed the fluid metal is promptly covered with a layer of oxide which makes the welding almost impossible, and there is great danger of burning holes.

Bernardo uses as a source of current seven sets of accumulators in parallel, each set 70 cells in series. These he charges while working by a shunt dynamo giving 120 amperes at 175 volts. He uses special battery plates made of lead strip, as he has found that "pasted" cells will not stand the heavy charge and discharge currents he employs. Messrs. Rothschild had great trouble at Creil from using "pasted" plates.

The E. M. F. and current required depend on the size, etc., of the work to be done. As an example, to weld together two pieces of ⅜-in. boiler plate, 40 cells in series and three in parallel would be taken, one end joined to the plates, and the other by a flexible lead to a 1-in. carbon rod in a portable holder.

The metal is then touched with the rod, which is immediately withdrawn from $\frac{1}{4}$ to $\frac{1}{2}$ in., thus striking an arc. The metal at the point where the arc forms melts immediately, like so much wax, and runs perfectly fluid. Through the dark spectacles the arc appears like a blowpipe flame, and is manipulated much as if it were one. If

the effect is too strong, and the metal boils and evaporates, ewer cells in parallel are used; if the arc goes out too often more are added in series.

If heavy pieces of metal of high melting point are to be joined, large currents and E. M. F. must be used, the carbons being proportionately larger, and *vice versa.*

The action of the arc is, like of a blow-pipe flame, very local; only that part of the metal which requires to be melted is much heated, and the moment the arc is removed

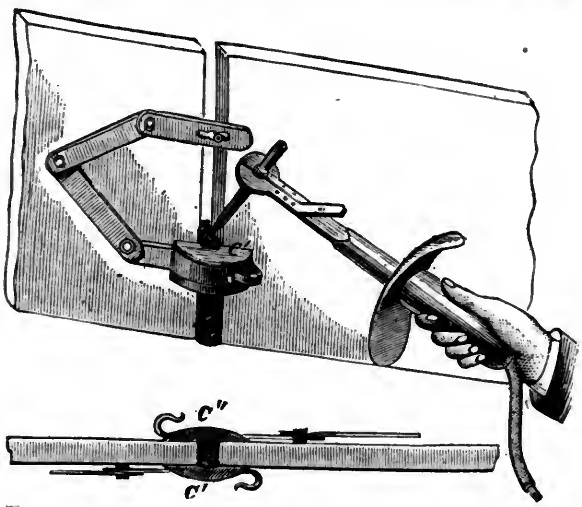


Fig. 1.

the fluid metal solidifies. The most refractory metals are instantly liquefied, and the work can be done with great rapidity.

The metals to be operated on require hardly any previous preparation, as with the high E. M. F. and currents used even a heavy coating of rust is at once fused. A little sand is used to unite with any oxide not reduced, and the slag thus formed protects the finished part from the oxygen of the air while cooling.

It is a great advantage in Bernardo's method over ordinary welding that the heat can be so easily taken to the place required, instead of having to bring the metal to the forge. In repairing a boiler, for instance, there is a good example of the extreme simplicity and convenience of the method. The negative lead is attached to any part

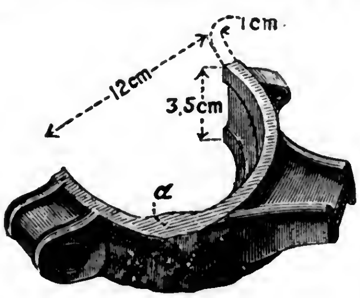


Fig. 2.

of the boiler by a small vice on the left hand, and then by taking the positive carbon-holder in the hand any part of the boiler can be operated on.

Besides welding two pieces of steel, wrought or cast iron, etc., together, the process has been used to join with

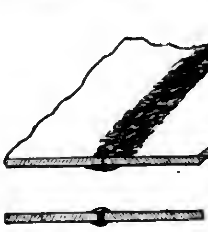


Fig. 3.

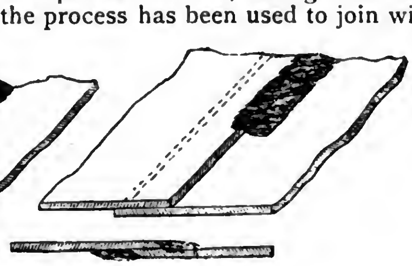


Fig. 4.

copper, tin, zinc, brass, lead, steel, or cast iron, as also to weld copper and brass, brass and brass, etc., and to coat iron with copper, tin, and lead. It may also be used to cut up as well as join a piece of iron plate, etc., as the metal runs off like water if no means are taken to retain it; and it may be noted that the process may even be used *under water* both for welding and for cutting metals.

Since the action is so rapid, and the metal so quickly cooled after welding by conduction to the surrounding

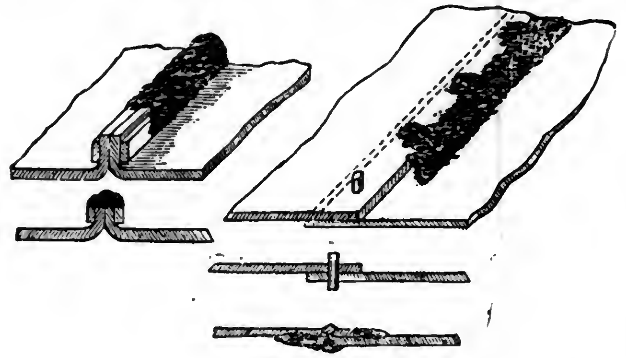


Fig. 5.

parts, there is no time for any appreciable chemical action to take place, as the following analysis shows:

Analysis.	Steel.		Iron.	
	Unworked.	Melted.	Unworked.	Melted.
Iron	98.86	99.39	98.90	99.43
Carbon	.48	.25	.34	.14
Silicium	.04	trace.	trace.	trace.
Manganese	.50	.25	.50	.23
Sulphur	.04	.04	.14	.09
Phosphorus	.08	.07	.12	.11
	100.00	100.00	100.00	100.00

The "melted" columns are analyses of pieces obtained by allowing the fluid metal to run off under the arc instead of retaining it in place. A further advantage of joining metals electrically is that nothing of the nature of a solder

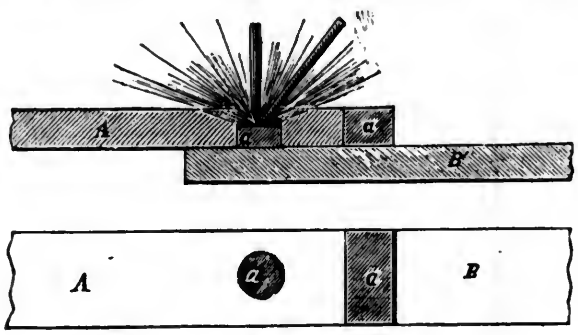


Fig. 6.

with different chemical and physical properties to the metals treated is employed, and that the joint is extremely little, if at all, weaker than the original metal.

Fig. 1 shows the method used for joining two upright

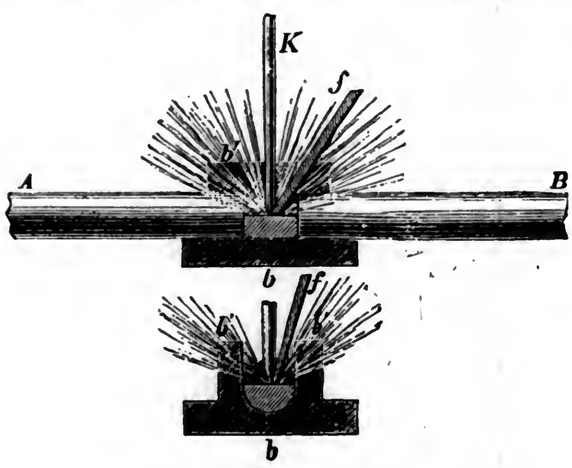


Fig. 7.

plates. *C' C''* are carbon blocks to keep the fluid metal in, and are shifted up from time to time as the joint is made.

Fig. 2 is a cast-iron eccentric strap, which was broken with a hammer at *a*, and then mended by fusing it together

with small pieces of rolled iron, a little sand being used as flux. In this figure the dimensions are given in centimeters. In this case the joint is perfect, and neither hard nor brittle.

Figs. 3 and 4 show butt and lap joints, and fig. 5 a pair of plates in process of being electrically riveted. Fig. 6 shows what may be called a "semi-riveted" joint. The upper plate only is punched, and a sort of rivet of molten metal built up in the hole, the edge of the upper plate being welded on the lower in addition. In this figure a piece of iron is shown which is being fused down to fill up the gap.

Fig. 7 shows two pieces of a thick iron rod being joined, a carbon block being used to retain the molten metal. In this figure also *f* shows a piece of iron being fused down to fill the space.

Among other uses may be mentioned that of welding fine steel on to a cast-iron body for tools, etc., without any risk of the steel being burned, and for filling up blow-holes which may only have been discovered after a considerable amount of work has been done on a piece of metal.

UNITED STATES NAVAL PROGRESS.

An important bill has been introduced in Congress by Mr. W. C. Whitthorne, of Tennessee, and referred to the Naval Committee. The bill has been carefully prepared, and is said to have such strong influences in its favor that the probabilities are that it will be reported and pass with but little amendment. It is of so much importance that we give it below in full.

THE NAVAL RESERVE.

Sec. 1. It shall and may be lawful in the enrollment of the militia of the several States and Territories bordering on the sea and lake coasts, or navigable rivers, to separately form and designate as the Naval Militia, between the ages of 18 and 45, all seafaring men of whatever calling or occupation, and all men engaged in the navigation of the rivers, lakes, and other waters, all persons engaged in the construction and management of ships and craft, or any part thereof, upon such waters, together with shipowners and their employés, yacht owners, members of yacht clubs and all other associations for aquatic pursuits, and all ex-officers and enlisted men in the Navy.

Sec. 2. The several States and Territories, having enrolled under sec. 1 a naval militia, shall be authorized to organize under their militia laws from persons composing the naval militia and others such commands as may volunteer to form portions of the following naval reserve forces: First, a Naval Reserve Artillery; second, a Naval Reserve Torpedo Corps. When so organized and reported by the governors of the States or Territories to the Navy Department, the Secretary of the Navy shall be authorized to supply arms and equipments, and naval vessels when it can be done without injury to the service, for instruction and drill.

Sec. 3. That the battery, to consist of not less than four officers and 80 petty officers and men, shall be the unit of the Naval Reserve Artillery, and that the crew, to consist of not less than one officer and 16 petty officers and men, shall be the unit of the Naval Reserve Torpedo Corps, and that the further organization, the officering, equipment and uniform of the above forces shall be prescribed by regulations established by the President, provided that the officers shall be selected and commissioned by the State authorities, and that if found qualified by a board of naval officers, appointed by the Secretary of the Navy, they may be commissioned by the President in the same titles and grades; and provided further, that the holders of such commissions shall have no claim upon the United States for compensation except when called into service by the President for war or training purposes.

Sec. 4. That the Naval Reserve forces may be called into the service of the United States under the following circumstances, and with the following conditions: First, in all cases where existing laws authorize the President to call out the militia; second, for a period of annual drill at such places as the President may designate, not to exceed one month; third, when so called into the service of the United States, the officers and men of the Naval Reserve forces will receive transportation from and to their homes, and pay and allowances similar to those allotted to the same grades and ratings in the regular naval service; fourth, it shall be the duty of the Secretary of the Navy to prescribe general regulations for the execution of the above article and the other provisions of this act.

Sec. 5. That annual mileage compensation, based on tonnage, speed, and steaming distance, shall be paid to the owners of such steam vessels now built and pronounced suitable for auxiliary cruisers by a board of naval officers appointed by the Secretary of the Navy, or which may hereafter be constructed in accordance with the requirement of the Secretary of the Navy; provided, that such vessels shall be engaged in the lake, coasting, or foreign trade, and shall sail under the flag of the United States; and provided, further, that to entitle such a vessel to the annual mileage, one-half her crew, exclusive of stewards, cooks, and servants, must be American citizens.

Sec. 6. That steamers so selected or constructed shall be built of iron or of steel, shall be capable of mounting not less than two high-powered rifles of a minimum caliber of 5 in., shall satisfy the requirements of the Navy Department as to speed, capacity for protection, coal endurance, and general fitness, which requirements may be modified from time to time, and shall be borne upon the navy register as first or second-class auxiliary cruisers.

Sec. 7. That the amount of the annual mileage paid for a steamer under the provisions of this act shall be determined by a board, consisting of three representatives of the shipping interests and three naval officers, and may be modified from time to time, subject to the approval of the Secretary of the Navy; provided, that the maximum mileage for any vessel in the foreign trade shall not exceed 30 cents per ton of net tonnage per 1,000 miles, and that the maximum mileage for any vessel in the coasting trade shall not exceed 20 cents per ton of net tonnage per 1,000 miles, and that the maximum mileage for any vessel in the lake trade shall not exceed — cents per ton of net tonnage per 1,000 miles; and provided, that no mileage shall be paid for any vessel in the foreign, coasting, or lake trade whose sea speed for 24 hours is less than 14 knots; and provided, further, that the maximum mileage shall not be paid for any vessel whose sea speed for 24 hours is less than 18 knots.

Sec. 8. That the United States shall have the right to take any vessel for which an annual mileage is paid for temporary or permanent use in time of actual war, or when an outbreak of war is imminent, and that the Secretary of the Navy shall agree upon the terms of charter or purchase with the owners, and shall execute a provisional contract with them to this effect for a stated term of years, which contract shall be renewed from time to time, and shall contain a provision forbidding sale or charter to a foreign flag without the consent of the Secretary of the Navy; provided, that no mileage shall be paid for a ship unless such a contract has been in force during the time for which the mileage is paid; and provided, further, that the owners of a vessel for which mileage is paid shall be held in bonds of —— for a faithful performance of their contract.

Sec. 9. That the officers and men between the ages of 18 and 40, serving in yachts and merchant vessels of the United States, and who are citizens of the United States, who shall so elect, and who shall be found physically and professionally qualified by a board of naval officers appointed by the Secretary of the Navy, shall be enrolled in a naval reserve, for periods not exceeding five years, in grades and ratings for which they may be found qualified, and which shall be established by the President, corresponding to grades and rating existing in the Navy; provided, that such officers and men shall be held to be in the United States service during such period of enrollment, and may be called into active service in time of actual war, or when the danger of war is imminent, and shall obey such call under the pains and penalty of desertion; provided, further, that whenever the owner, officers, and seamen of a yacht propose to enroll themselves and vessel as a part of the auxiliary navy of the United States, with-

out cost to the Government, and the said vessel shall be approved by the Secretary of the Navy as fit for dispatch, torpedo, or other auxiliary naval service, he is authorized to enroll the same ; and provided, further, that the officers and men of the life-saving service, the light-house service, the revenue marine, and the coast signal service may be enrolled in the naval reserves, and may be assigned to such duties and receive such annual instruction in naval warfare as the President may prescribe.

Sec. 10. That each officer and man of the navigating naval reserves shall be required to report in person once each year to such naval authority as the Secretary of the Navy may select, and shall satisfy such inquiries and examinations prescribed by the Navy Department as may be necessary to ascertain his continued fitness for duty ; and upon the completion of this annual requirement each officer shall receive $50, each petty officer $25, and each man of inferior rating $20 ; provided, that no annual premium shall be paid except when this report in person is made ; and that if the examination shows unfitness for duty in the grades of rating held by any navigating naval reserve officer or man, he shall be at once discharged from the service without further compensation.

Sec. 11. That the navigating naval reserves shall not be called into active service in time of peace, but such officers and men of this branch as may elect to join the colors for naval training during the period of annual drill of the organized reserve forces shall be mustered into the naval service of the United States for that period, and shall receive the same pay and allowances as the organized reserve forces.

Sec. 12. That a yacht commanded by an officer of the naval reserves, or a merchant vessel so commanded, and which shall have in her complement five other officers and men belonging to the naval reserves, shall have the right to fly from her mainmast head a burgee with the letters "U. S. N. R.," provided, that the color, shape, and size of such burgees shall be prescribed by the Secretary of the Navy, and that the burgees shall be furnished by the Navy Department.

Sec. 13. That all officers of the naval reserves holding commissions from the United States shall be borne upon the naval register under their respective classifications—namely, naval reserve artillery, naval reserve torpedo corps, and navigating naval reserve.

Sec. 14. That the entire organization, administration, training, and control of the naval reserve forces exercised by the Government of the United States shall, under the direction of the President, be confided to the Secretary of the Navy, who is hereby authorized to detail, at the request of State authorities, officers and petty officers of the navy to act as inspectors, instructors, and assistant instructors of the naval reserve artillery and torpedo corps, and to be the responsible custodians of the property of the United States issued for the training and arming of the said forces.

Sec. 15. That, to promote seamanship, and to improve the qualifications of the navigating naval reserve, the Secretary of the Navy is hereby authorized to supply a detail of naval officers to any schoolship for training boys in seamanship and navigation which may be established by the authorities of a State ; provided that all expense of purchase or hire and equipment of such schoolship shall be borne by the State establishing it ; and provided, further, that no schoolship so established and officered shall be used in any sense as a reformatory institution.

Sec. 16. That all laws and sections of laws conflicting with the provisions of this act are hereby repealed.

TRIAL OF THE "CHICAGO."

Captain H. B. Robeson, who commanded the new cruiser *Chicago* on her trial trip on Long Island Sound, shortly thereafter made a report to the Navy Department. During the trial the weather was clear, with a strong breeze and moderate gales from the northward and westward. As far as observed, the force of the wind did not affect the speed, the ship having no top-hamper whatever. The sea was moderate, except in that part of the Sound to the eastward of Stratford Point, where a slight swell from the northwest was experienced. The distance run was carefully noted by bearings of objects on shore, by two patent logs and the log chip, these observations, as far as possible, being taken every half hour. These data, with an allowance for the tide, are given in a tabulated record of speed accompanying the report, showing that the distance recorded by the log was slightly below the actual distance shown by the bearings. The run was extended further to the eastward than was at first intended, owing to the temporary disability of the steering engine. One of the eccentric straps became loose, and made necessary a change from steam to hand, and as it was found desirable to make the run with the steam steerer, a slight delay occurred in the time of running. The steerer again became disabled from the same cause, and the ship was steered by hand during the last hour of the run. The six-hour trial was finished at 3.30 P.M., the ship having run 85.30 nautical miles by the chart, or, with the allowance for tides, 90.63 nautical miles. The mean speed obtained during the run was 15.1 knots, and the maximum speed for any one hour was 16.35 knots. The mean H. P. developed was 5,084, and the maximum for one hour, 5,248. The machinery worked smoothly for the entire run, and though water was occasionally used on the journals, the engines were not stopped or slowed down at any time during the trial. The engines worked quickly and efficiently, and all signals from the deck were promptly answered. During a temporary adjustment of the steam steerer the ship was easily handled in the East River by working the twin screws. No report is made of the air pressure, as it was not considered either desirable or necessary to close the fire-rooms. All the steam that could be worked through the engines was furnished by the blower assisting the natural draught. Chief Engineer Henderson reported that the ability of the fire-rooms to maintain the air pressure required by contract was proved by tests at Chester.

The ship steers well, and when the steering engine is properly adjusted and a few minor defects corrected the steam steerer will give satisfactory results. The steam capstan did not work well, and much difficulty was experienced in weighing the anchor. The reversing gear of the anchor engine does not work at all, and its present condition is useless. Captain Robeson says that some arrangement should be also made to keep the chain on a level with the barrel of the capstan. The pawls on the gun-deck capstan were all broken, and should be replaced with pawls of wrought iron. Owing to the horizontal position of the anchor engine attached to the lower side of the main deck the vibrations in working the engine are excessive. The steam trial clearly showed the necessity of making different arrangements regarding the fire-room hatches. It is probable that the maximum speed corresponding to the developed H.P. was not made on this trial because of the foul condition of the vessel's bottom.

The *Chicago* has two compound engines with cylinders 45 in. and 78 in. diameter and 57½-in. stroke. The engines differ from those of the other new cruisers ; they are of the beam pattern, the cylinders being vertical and the connecting rods coupled to overhead walking-beams. This design was presented by the civilian members of the Advisory Board, which adopted the plans.

The boilers are also somewhat peculiar in design ; they are fired from their lower exterior surface, the furnaces being entirely outside. These furnaces are of firebrick in a wrought-iron casing. There are six boilers to supply the main engines, with two for the auxiliary engines.

On the trial the mean pressure carried, with natural draft, was about 87 lbs. on the main boilers.

Quadruple-Expansion Marine Engines.

(From the London *Engineering*.)

QUADRUPLE-EXPANSION engines of the type patented by Mr. Walter Brock, of the firm of Denny & Co., Dumbarton, and of which a brief notice was given in a late issue of *Engineering*, have recently been brought into use on the screw steamer *Kron Prinz Friedrich-Wilhelm*, one of the large fleet owned by the North German Lloyd Company. The new cylinders, boilers, etc., were made in Dumbarton by the firm just mentioned, and shipped to Bremerhaven, where they were fitted to the old engines by the workmen of the owners ; and the time for completing

the work, and the high style and finish, reflect the greatest credit on the engineering staff of the Norddeutscher Lloyd Company. Messrs. Boénig and Knaffl, the company's superintendents, had the work of conversion under their special supervision; and Mr. Stirling represented the Dumbarton engineering firm.

The dimensions of the steamer are: Length, 318 ft.; breadth of beam, 39 ft. 6 in.; depth, 31 ft. Prior to her conversion she had a pair of engines constructed on the old system, the cylinders being 48 in. and 88 in. in diameter, with piston stroke of 48 in.; and the steam that was supplied to them was of 60 lbs. pressure, and generated in four single-ended boilers.

In their converted form the engines have cylinders of 21½ in., 30½ in., 43 in., and 61 in. in diameter, respectively, with piston stroke the same as formerly. They are supplied with steam of 170 lbs. pressure from two double-ended boilers, which have a heating surface of 4,338 square feet, and a grate surface of 173 square feet. In the engine-room there are placed two of Messrs. Weir's patent pumps, and the distiller and feed-heater of the same firm. The patent combined steam and hydraulic starting gear of Messrs. Brown Brothers, Edinburgh, is also supplied. The circulating pump in the old engines has been done away with, and its place is filled by one of Messrs. Gwynne's patent centrifugal pumps.

The trials of the steamer with her converted engines took place on the Weser in the early part of last month, when results were obtained which cannot but be regarded as highly satisfactory. Tested on the measured mile, and between the lights, the *Kron Prinz* maintained a mean speed for six hours of 13.19 knots, which is a considerable increase over her previous performances. At the same time trials were made of the consumption of fuel, the results of which thoroughly satisfied the representatives of the Norddeutscher Lloyd Company. During the trials the engines indicated about 1,700 H. P. In consequence of the greatly increased economy of the engines now in use on board the *Kron Prinz*, the owners have been enabled to convert a considerable portion of the coal bunkers into cargo-carrying space.

When taken in conjunction with the results of the trials lately made with the steamer *Tenasserim* on the Clyde, the results obtained with the *Kron Prinz* abundantly show that shipowners have now placed before them an economical and efficient mode of making vessels—possibly not old in years, but behind date in their machinery—able to hold their own with their more modern competitors. There is likewise the important fact that Messrs. Denny & Co. have a considerable number of vessels in hand for the conversion of their engines in the same way. The engineers were represented at the trials by Mr. Brock, the patentee. The *Kron Prinz* will shortly leave, if she has not already left, on a voyage to Buenos Ayres, the results of which are being looked forward to with a great degree of interest; and it is confidently anticipated that they will amply confirm the good impression formed regarding the new machinery by the owners at the trials on the Weser. The engines are under the charge of Mr. Schultze, one of the company's chief engineers.

The American Iron Trade in 1887.

(From the *Bulletin* of the American Iron and Steel Association.)

THE year which has just closed was one of great activity and fair prosperity for the iron trade of this country. Production in all leading branches of the manufacture of iron and steel was the largest in our history—larger than in the remarkable year 1886, when all previous achievements were left far behind. We estimate our production of pig iron in 1887 at 6,250,000 gross tons, or about 600,000 tons more than in 1886, when our production was 5,683,329 tons. Our production of Bessemer steel rails in 1887 was about 1,950,000 gross tons, or about 375,000 tons more than in 1886, when our production was 1,574,703 tons. In addition to our large production of pig iron in 1887 we also consumed about 500,000 tons of imported pig iron and about 160,000 tons of imported steel rails. Our imports of iron and steel in other forms in 1887 were also very large, the total importations of iron and steel in all forms aggregating nearly 1,800,000 tons. Our production of iron ore in 1887 was about 11,000,000 gross tons, and our imports in the same year amounted to about 1,250,000 tons. In 1886 we produced about 10,000,000 gross tons of iron ore and imported 1,039,433 tons.

The impetus which had been given to the domestic iron trade in the closing months of 1885 and which had been so much accelerated in 1886 that the year closed with excited markets was still further emphasized in the first six months of 1887, during which period the demand for all forms of iron and steel was active and constant. Prices of steel rails advanced during these six months, but other prices generally declined. After the middle of the year all prices fell off in sympathy with the general conviction that the remarkable activity of the preceding year and a half could not much longer be maintained, especially the phenomenal demand for steel rails for new railroads. The following table gives the monthly range of prices for eight leading products during 1887, averaged from weekly quotations.

MONTHS.	Old iron 'T' rails, at Philadelphia.	No. 1 anthracite foundry pig iron, at Philadelphia.	Gray forge pig iron, at Philadelphia.	Gray forge pig iron, Lake ore mixed, at Pittsburgh.	Steel rails, at mills in Pennsylvania.	Best refined bar iron, from store, at Philadelphia.	All muck bar iron, at Pittsburgh.	Iron nails (gross price), at Pittsburgh.
	$	$	$	$	$	cts.	cts.	$
January	25.25	21.50	18 50	20.50	38.50	2.15	2.00	2.35
February	24.00	21.50	19.00	21.00	39.50	2.25	2.00	2.60
March	23.00	21.00	19.00	20.50	39.50	2.30	2.00	2.60
April	22.75	20.75	18.50	20.25	39.25	2.30	2.00	2.35
May	21.85	20.85	18.00	19 00	39.00	2.30	2.00	2.15
June	22.60	21.00	17.85	18.50	39.00	2.20	2.00	2.05
July	23.50	21.00	17.60	18.50	38.50	2.20	1.90	2.00
August	24.00	21.00	17.25	18.50	37.00	2.20	1.90	2.00
September	22.75	21.00	17.00	18 50	36.00	2.20	1.90	2.00
October	22.00	20.50	17.00	18.25	34.25	2.15	1.90	2.00
November	22.00	20.50	17.00	17 75	32.50	2.10	1.90	1.85
December	22.00	20.50	16.75	17.00	32.50	2.10	1.85	1.90

The decline in the demand for steel rails, foreshadowed soon after the middle of the year, was clearly visible in August, more noticeable in September, and a subject of general comment and some apprehension in October. In that month the steel-rail manufacturers met at Philadelphia, and unanimous action was taken, which has since had the effect of steadying the market. Several mills were closed in December through a scarcity of orders at remunerative prices, and it is understood that some of these will remain closed and that others now running will close if the policy of leading railroad companies in withholding orders until prices can be still further reduced is not changed. Prices of steel rails fell $6 during the last six months of the year, compelling at its close a very general reduction at steel-rail mills of about 10 per cent. in wages. If still lower prices for steel rails could be accepted a further reduction in wages would become absolutely necessary.

The manufacturers of pig iron were compelled to pay high prices for Lake Superior iron ore and Connellsville coke all through the year. No. 1 specular and magnetic Bessemer ore at Cleveland ranged from $7 to $7.50 from January to December. The advance on all grades in 1887 averaged over $1 per ton as compared with 1886. Connellsville coke was advanced from $1.50 to $2 on February 1, and this price was continued until the close of the year. Concessions upon these prices are now absolutely necessary.

Notwithstanding the decline in demand and prices which has been noted, it would not be correct to assume that the new year opens with general depression in our iron and steel industries. The shrinkage in demand is most marked in steel rails, and is next most noticeable in pig iron, bar iron, and iron pipe. But the consumption of pig iron for miscellaneous purposes is still very large, and the steel-rail manufacturers know that a large quantity of steel rails will be needed in 1888 for renewals and extensions as well as for a large mileage of new road which must be built. The bridge works of the country, the foundries,

the machine shops, the car-builders and car-wheel manufacturers, the locomotive builders, and many other consumers of iron and steel are still very busy.

We do not recall one serious strike in the iron trade of this country during 1887. There was dissatisfaction with the wages paid at various places, but the difficulties were soon healed. A protracted strike of miners and coke-drawers in the Connellsville coke district in the spring and early summer seriously interfered with the supply of coke to blast furnaces, about 50 of which were banked or blown out for several weeks. In September a strike of miners occurred in the anthracite region of Eastern Pennsylvania, which has thus far only been broken in part and which has slightly interfered with the production of pig iron in the region mentioned. Wages in the iron trade were generally advanced at the beginning of the year, but with falling markets it is too much to expect that this advance can be maintained in 1888. In addition to the reduction at some steel-rail mills which has already been noted, reductions have already taken place at some blast furnaces and a few other works.

The Nordenfelt Submarine Torpedo Boat.

(From the London *Engineer*.)

THE first approach to any official trial of the Nordenfelt submarine vessel took place December 19. It was not by any means a formal official trial, but the boat has been matured to a sufficient extent to exhibit its powers and capabilities, allowance being made for want of practice. The opportunity of witnessing such a trial was seized by representatives from the Admiralty, Ordnance Committee, Royal Engineers, and the naval attachés of foreign Powers. As our readers generally are aware, the object of this boat is to approach a ship under water, so as to escape observation, and thus discharge a torpedo in such a way as to strike an enemy with certainty, and in a vital place. In her ordinary mode of progression the vessel lies very low in the water, and is much less visible than a service torpedo boat. She would approach an enemy thus till she reached a distance at which she might run in danger of being perceived, perhaps from 2,100 to 2,500 ft.; then she would close all escape for smoke and all passage for air, and sink so low that nothing remains above water but two small gloss domes fixed at the top of two cupolas. These domes are sufficiently large to contain a man's head, one in the fore part of the ship and one aft. In this position the vessel would depend on her store of steam provided for as hereafter described, and her crew on her imprisoned air. The captain takes his stand with his head in the forward dome, a position which, it is said, gives him a singularly clear view along the surface of the water at night for such distances as are not affected by limit of horizon. Close to his hand are the handles or levers for regulating the speed and the direction of the boat, also the working of the horizontal propellers employed for descending below the surface. For rising again no propeller is necessary, the system being to adjust the boat to float with the surface of a wooden deck—which has recently been added as a superstructure—nearly level with the surface of the water. As the boat eventually nears her enemy, she descends entirely under the water, so that nothing is visible except the eddies on the surface formed by the revolution of the horizontal propellers, and these would probably be seen only in smooth water. This boat, the *Nordenfelt*, is intended to carry four, possibly five, torpedoes. Obviously the discharge of these will need skill and practice in a system so nicely adjusted. Nothing has been as yet carried out in this direction. The trial with which we now deal related exclusively to the working of the boat and to the handling of it in submerging it or in bringing it to the surface. The form of the boat, which is 135 ft. long and 12 ft. in beam, is not here discussed, because it can be best seen by drawings. Captain T. Garrett, who has had considerable experience with a submarine boat of a cigar form, has found this one much more manageable.

Two trials took place in the afternoon in Southampton water near the lightship; the first consisted in running the vessel at fast speed when in the highest position—that is, with the flat deck or superstructure a few inches above the surface of the water, in which condition the displacement is 160 tons; when submerged it is 230 tons. The object was to enable those who witnessed the trial to judge how far the boat was visible and how far vulnerable in comparison with a service torpedo boat. The superstructure is, of course, not of any vital importance. Beneath it the boat is protected by a turtle-back of steel 1 in. thick, and the conning towers or cupolas by 1 in. of steel. It is intended in future vessels to increase this to 3 in. The boat thus running at high speed obviously offered a very small mark to artillery.

The boat acquitting herself well in this trial, as well as in descending below the surface and rising again, the tender, with the officials on board, moved off toward Southampton to wait for the *Nordenfelt* to attempt an approach after dark. It may be observed that there were several difficulties to be grappled with in this task—first, the tender carried only one indifferent light, and it was a good test of the finding powers of the *Nordenfelt* in its various conditions to discover and approach her; secondly, vessels were frequently passing which called for care and prudent handling of the *Nordenfelt* to avoid danger of collision; thirdly, the difficulties of manipulating the boat were for the moment increased by the recent addition of the superstructure, which altered all the levels and adjustments, which experience had taught best suited the boat in its different movements. The result of this condition of things was that considerable delay was experienced in the operations, and the spectators on the tender had a long wait of about four hours before the actual attack was achieved. The night was a very fair one for the purpose. There was a moon, but a considerable quantity of cloud. The water was calm and the night free from mist. The *Nordenfelt* approached, sinking in the water as she neared the tender, traveling submerged wholly for about 300 ft., and was not perceived until she had sounded a whistle from a position 210 ft. on the port bow of the tender. The *Nordenfelt's* rate of speed was about 3½ or 4 knots.

On the following morning the officials and other visitors went on board the *Nordenfelt* in the dock and had the various arrangements and features of the boat explained to them, and they witnessed the submersion and rising of the boat, which was repeated so as to show that it was completely under control. Altogether the trial was most successful, but there remains much to be done before the *Nordenfelt* can be brought into condition for actual service. The introduction and successful discharge of the torpedoes have to be mastered. Then great experience is needed for handling the boat below water. Not only has the speed been hitherto kept very low, but also every change in position has been slowly and carefully effected. With a cigar-shaped boat experience has shown that there is a great liability to plunge head down, which is very dangerous in water of limited depth; but the fact is that destruction, as Captain Garrett well expressed it, is always within a very limited number of feet. But the crew of a craft engaged in naval warfare has always to run risks, and the crew of the *Nordenfelt* would be very much safer than the men in an ordinary torpedo boat. The safety of this boat is mainly secured, first, by Mr. Nordenfeldt's plan of working her in a condition when the revolution of the horizontal propellers is necessary to keep her under water, so that in any stoppage or breakdown she rises at once; and secondly, by a reserve of hot water under pressure, which, if ejected by steam, gives very great power to rise, though in a condition of partly expended motive power and temporary helplessness. Altogether the physical questions involved are very interesting. To a ship attacking harbors in the future the various forms in which attack may come to her must be peculiarly interesting. From a dynamite gun, a torpedo in the shape of a huge dynamite or gélatine shell may come hurtling through the air and fall close to her. Near the surface of the water she may strike the circuit closer of a submarine mine lying near the bottom, and at any desired depth the Nordenfelt boat may approach and discharge a torpedo at her. Near a harbor, in fact, the air, the surface and the depths of the water to the bottom itself may bring surprises upon an enemy, and this from torpedo warfare alone.

CATECHISM OF THE LOCOMOTIVE.

(*Revised and enlarged.*)

BY M. N. FORNEY.

(*Continued from page* 42.)

CHAPTER VIII.

THE ACTION OF THE PISTON CONNECTING-ROD AND CRANK.

QUESTION 142. *What effect does the connecting-rod have on the relative movements of the piston and crank?*

Answer. The inclination of the rod, as shown by *E F* in fig. 81, to the centre line, *A B C*, of the cylinder causes the piston to move somewhat more than half its stroke while the crank is passing from 1 to 5, or during the first quarter of its revolution, and somewhat less than half its stroke during the second and third quarter, and again somewhat more during the last quarter of the revolution, or while the crank-pin is passing from 13 to 1.

QUESTION 143. *How can this effect of the inclination or "angularity," as it is called, of the connecting-rod be shown?*

Answer. It will be made apparent if we will draw a circle, *B C*, fig. 81, representing the path of the center of the crank-pin, and then divide it into 16 equal parts, 1 2, 2 3, 3 4, etc. From 1, which is the front dead-point of the crank, a distance 1 1′ will be laid off equal to the length from center to center of the journals of the connecting-rod, and from 9, the back dead-point of the crank, a distance 9 9′ is laid off also equal to the length of the connecting-rod; 1′ and 9′ then represent the positions of the center of the cross-head pin when the crank is at its dead-points and when the piston is at the ends of its stroke. As explained before, the cross-head and the piston are rigidly connected together, so that the motion of the one represents that of the other. The movement of the center of the cross-head pin may therefore be regarded as the same as that of the piston. If now, with a pair of dividers, we take a distance equal to 1′ 1, or the length of the connecting-rod, and from 5 as a center a short arc, *E*, is described so as to intersect the center-line *A B C*, the point of intersection will represent the position of the center of the cross-head pin when the crank is at 5, or when it has turned one-quarter of a whole revolution. If we subdivide the distance 1′ 9′, which represents the stroke of the piston, into two equal parts, 1′ *a* and *a* 9′, then it will be found that the distance from 1′ to *E* is somewhat more than 1′ *a*, or than half the stroke of the piston. That is, while the crank-pin has moved from 1 to 5, or turned one-quarter of a revolution, the piston has traveled a little *more* than half its stroke. When the crank-pin reaches the dead-point at 9, then the cross-head pin will be at 9′, so that while the crank has moved through the second quarter of its revolution the cross-head pin and piston have traveled a distance, *E* 9′, somewhat *less* than half the stroke, *a* 9′.

Again, when the crank has reached 13, and has passed through the third quarter of its revolution, if we take the length of the connecting-rod, and from 13 as a center, with 13 *E* as a radius, describe another short arc, it will intersect *A B* again at *E*, so that while the crank-pin has revolved through the third quarter the piston has moved from 9′ to *E*, or *less* than half its stroke. When the crank again reaches 1 the cross-head pin will be at 1′, so that it and the piston have moved *more* than half a stroke while the crank passed from 13 to 1, the fourth quarter of its revolution. Owing to this *angularity*, as it is called, of the connecting-rod, the crank-pin is behind the piston during its backward stroke and ahead of it during the forward stroke.

QUESTION 144. *How does the action of the connecting-rod influence the motion of the valve in relation to the piston?*

Answer. As the crank moves slower than the piston during the first and last quarter of the revolution, and as the valve is moved by the eccentric, and it in turn by the shaft and crank, consequently the movement of the valve is delayed in relation to that of the piston during these periods. As the crank moves faster than the piston during the second and third quarters, the points of cut-off and release occur earlier in the stroke during these periods than they do during the first and fourth quarters of the crank's revolution.

This is not, however, a matter of very great practical importance with stationary engines which run at comparatively slow speeds; but if it is thought desirable, the period of admission and the point of release for both strokes can be equalized, either by giving the valve more lead or lap at one end than the other, or by making the one steam-port wider than the other. The mechanism employed for moving locomotive slide-valves, however, furnishes us with the means of modifying their motion in relation to that of the piston, and of thus equalizing the periods of admission and release for the front and back strokes. The methods of doing this will be more fully explained hereafter.

QUESTION 145. *What effect does the angularity of the connecting-rod have on the cross-head and slides?*

Answer. When the crank is revolving in the direction represented by the dart *F* in fig. 81, the connecting-rod is plainly subjected to a compressive strain while the piston is moving backward or toward the shaft, and during the first half of the revolution of the crank. The pressure on the cross-head and guides due to the angle of the rod is therefore upward. When the piston is moving from the shaft, or making its forward stroke, and the crank is passing from *C* to *B*, the connecting-rod is then in tension, and the pressure on the cross-head and guides is again upward. If, however, the crank should revolve in the opposite direction from that represented by the dart, the pressure on the cross-head and guides would be downward—that is, the direction of the pressure on the guides is reversed when the direction of the revolution of the crank is reversed, or when the engine runs backward.

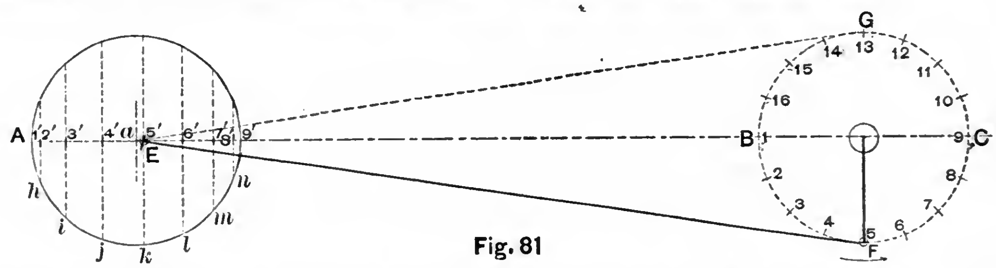


Fig. 81

QUESTION 146. *What is the nature of the motion of a piston of a steam-engine during each stroke?*

Answer. When it is at the end of the cylinder, and the crank is at one of the dead-points, the piston is momentarily at rest or stationary. After it starts its speed is increased up to a point near the middle of the stroke, where it reaches its maximum velocity. From that point the speed is diminished to the end of the stroke, when it again comes to a momentary state of rest before beginning the return stroke. During the return stroke its motion is almost exactly the same, excepting that the direction of its movement is reversed.

QUESTION 147. *How can the motion of the piston be represented graphically?*

Answer. This can be done by constructing a diagram as shown in fig. 81. In this the circle *B C*, as already explained, represents the path in which the center of the crank-pin revolves and is divided into sixteen equal parts, 1 2, 2 3, 3 4, etc. Let it be supposed that the crank is turning in the direction indicated by the arrow *F*—which is the way a locomotive driving-wheel would move in running forward. If the crank is revolving at a uniform speed the crank-pin will move through each of the spaces 1 2, 2 3, 3 4, etc., in equal times. If we take a pair of dividers, with a distance between the points equal to the length of the connecting-rod, and then with 2 as a center we describe a small arc to intersect the center line *A B* at 2′, the point of intersection will be the position of the center of the cross-head pin when the crank-pin is at 2. The distance from 1′ to 2′ will then represent the movement of the cross-head and piston while the crank-pin was passing from 1 to 2. If we place one point of the dividers at 3 and describe another arc, 3′, intersecting the center line *A B*, then the distance 2′ 3′ will be that which the cross-head has moved while the crank-pin was passing from 2 to 3. If in a similar way we draw successive arcs 4′ 5′ 6′, etc., from 4, 5, 6, etc., as centers, then the spaces 3′ 4′, 4′ 5′, 5′ 6′, etc., will represent the movement of the cross-head and piston while the crank-pin is passing over the successive spaces laid out in the circle *B C*. An inspection of the spaces 1′ 2′, 2′ 3′, 3′ 4′, etc., will show that they successively increase from the beginning to near the middle of the stroke of the piston, and they then diminish from near the middle to the end

of the stroke. The movement of the piston during its forward stroke is the same as that represented in the diagram, but in a reversed direction.

QUESTION 148. *How can the velocity of the piston during any portion of its stroke be ascertained?*

Answer. In explaining this, it will first be assumed that the stroke of the piston is 2 ft., and that the crank is moving in its path $B\ C$ at a velocity of 30 ft. per second.

It should be noticed that a point like the center of a crank-pin which is moving in a circle is constantly changing the direction of its motion. At any one instant of time, however, it moves at right angles to the center line of the crank. Thus, when the crank $F\ S$ is in the position shown in fig. 82, the line $a\ F$ drawn at right angles to $F\ S$ represents the instantaneous direction in which F is moving when in the position represented. If the length of $a\ F$ represents the velocity—20 ft. per second—of the crank-pin, then by the principles of the composition of motion, if this line is made the diagonal of a parallelogram $a\ b\ F\ d$, of which the two sides $a\ b$ and $d\ F$ are horizontal and $a\ d$ and $b\ F$ vertical, then these sides will represent the horizontal and vertical velocity of the center of the crank-pin. As the horizontal movement of the crank-pin is nearly coincident with that of the cross-head and piston, the motion of these latter parts being communicated to the crank-pin by the connecting-rod, therefore the line $d\ F$ or $a\ b$, which represent the horizontal velocity of the crank-pin, will also represent very nearly the velocity of the cross-head and piston. Similar diagrams for other positions of the crank are given in figs. 83 and 84, in which the horizontal lines $d\ F$ represent approximately the horizontal velocity of the crank-pin and piston.

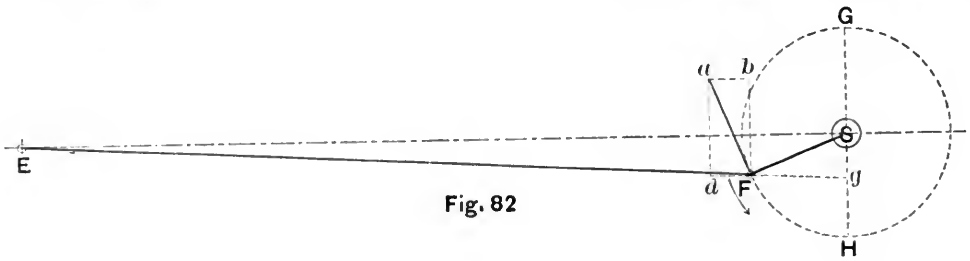


Fig. 82

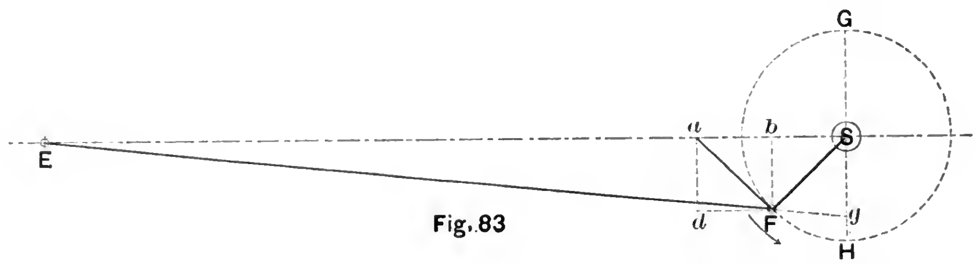


Fig. 83

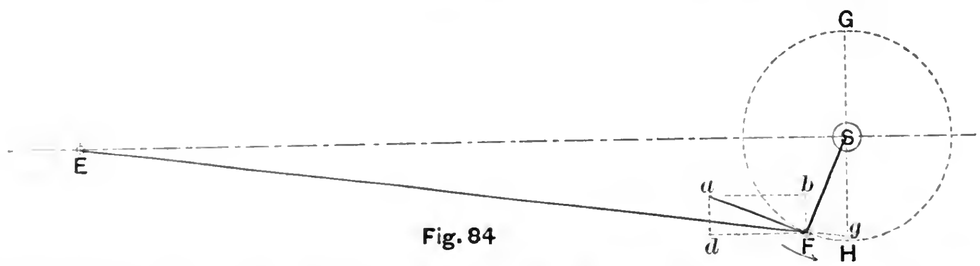


Fig. 84

QUESTION 149. *What effect has the connecting-rod on the velocity of the piston?*

Answer. As already explained, the velocity of the piston is accelerated by the connecting-rod while the former is moving from the front end of the cylinder to the middle of the stroke and again when it moves from the middle to the front end. It is correspondingly retarded at the other end of the cylinder.

QUESTION 150. *Do the diagrams in figs. 82, 83 and 84 represent the velocity of the piston precisely?*

Answer. No; they do not show the effect of the angularity of the connecting-rod.

QUESTION 151. *How can a diagram be drawn which will show the velocity of the piston correctly?*

Answer. This can be done if the line $a\ F$, figs. 82, 83 and 84, which represents the circumferential velocity of the crank-pin, is made equal to the radius $F\ S$ of the crank. Then if the line $E\ F$, which represents the center line of the connecting-rod, is prolonged so as to intersect a vertical line $G\ H$, figs. 82, 83, and 84, drawn through the center of the shaft S, the line $g\ S$ will represent correctly the velocity of the piston. If the crank-pin is in a position on the right side of $G\ H$, then the distance of g, the point of intersection of $E\ F$ with the vertical line from the center, S, of the shaft, will represent the velocity of the piston.*

QUESTION 152. *How can the velocity of the piston be shown during its whole stroke?*

Answer. It has been explained how the velocity at any one point may be ascertained. We may determine the velocity for each of a number of successive points of the stroke, and then construct a diagram which will represent graphically the rate of speed or velocity of the piston during a whole stroke of the piston or revolution of the crank. Thus, fig. 82 represents the crank in the position marked 2 in fig. 81. The center line $E\ F$ of the connecting-rod is extended to g, so that $g\ S$ represents the velocity of the piston at the instant that the crank-pin is at 2, fig. 81. From 2′, the corresponding position of the cross-head pin, a perpendicular, 2′ h, is drawn downward equal to $S\ g$ of fig. 82. In fig. 83 the crank-pin F is in the position 3 of fig. 81. The center line $E\ F$ of the connecting-rod is again extended to g, and the distance $S\ g$ is laid off from 3′, the corresponding position of the cross-head pin, to i. In the same way the velocity of the cross-head pin is plotted for each of its positions, 4′, 5′, 6′, 7′, and 8′, and a curve, $A\ h\ i\ j\ k\ l\ m\ n$ 9′, fig. 81, is drawn through the extremities of the perpendicular lines. The perpendicular distance of this curve *below* the center line $A\ B$ represents the velocity of the cross-head pin and piston for each point of the backward stroke. A similar curve has been drawn above the line $A\ B$, and shows the velocity of the piston during its forward stroke.

QUESTION 153. *What is shown by the form of these curves?*

Answer. It will be noticed that the curves are not a true circle, but somewhat egg-shaped—that is, the left-hand or front portion of each of them is fuller than at the other end, showing, as has already been pointed out, that the velocity of the piston, owing to the influence of the angularity of the connecting-rod, is somewhat greater during the first and last quarters of the revolution.

QUESTION 154. *Is any considerable amount of power required to accelerate the piston and other reciprocating parts of an engine during the first half of the stroke?*

Answer. Yes. In fast-running engines much more power is required to accelerate the reciprocating parts during the first half of each stroke than is usually supposed.

QUESTION 155. *How can this be shown?*

Answer. This will be apparent if we will compare the velocity of these parts with those of a falling body. To do this,

* The demonstration of this theorem would require the introduction of mathematical principles which would be out of place in an elementary book like this. The reader will find the whole subject very fully discussed in "A Practical Treatise on the Steam-Engine," by Arthur Rigg, and in George C. V. Holmes's excellent little book on the Steam-Engine.

it will be supposed that the cylinder of the engine is placed vertically above the crank, as shown in fig. 85, and that the cross-head starts from *A*. The curve *A h i j k l m n o* shows the velocity of the piston when the crank-pin is moving with a circumferential velocity of 30 ft. per second, which is equivalent to a speed of about 50 miles per hour for a locomotive having driving-wheels 5 ft. in diameter and 2 ft. stroke of piston. Another curve, *A n*, has been constructed to show the velocity which a body falling freely would acquire in a distance, *A g*, equal to the stroke of the piston. It should be observed that the horizontal distance of the two curves from the vertical line *A o* represents the velocities of the piston and of the falling body. They can therefore be compared with each other, and it will be seen that at the middle of the stroke of the piston its velocity is about four times that of the falling body. It must be remembered, as was explained in Chapter I, that the force which moves and gives velocity to a falling body is its own weight, or the attraction of gravitation, and that the velocity which a body acquires is proportional to the force acting on it. If, then, the reciprocating parts of an engine in moving a given

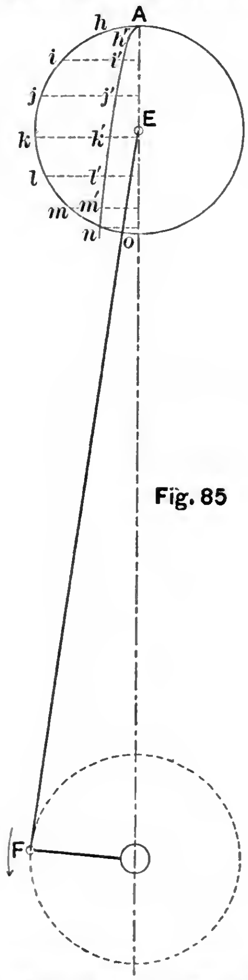


Fig. 85

distance have a velocity imparted to them four times as great as that which a falling body would acquire in the same distance, the force which acts on the reciprocating parts to produce this motion must be equal to over four times their own weight. As these parts of a passenger locomotive, with 18×24-in. cylinders, weigh about 550 lbs., the pressure on the pistons required to give them the required velocity in moving from the beginning to the middle of the stroke at a speed of 50 miles an hour must be equal to that produced by a weight of not less than 550×4=2,200 lbs. acting through a distance of one foot.

QUESTION 156. *Is the rate of the acceleration of the velocity of a piston the same as that of a falling body?*

Answer. No; a falling body can move freely under the action of the force which attracts or impels it downward, whereas the movement of the reciprocating parts of a steam-engine are restrained by the crank, which moves in its path at a nearly uniform rate of speed. The relative velocity of the piston and a falling body are shown by the form of the curves *A k o* and *A k' n* in fig. 85, from which it will be seen that in moving from *A* to *h* and *i* the rate of acceleration of the piston is very great, whereas from *i* to *j* it is very slight, and the motion begins to be retarded soon after it passes *j*. A falling body, as was explained in answer to questions 13 to 20, has a uniform increase of its velocity for every second that it falls.

QUESTION 157. *In what way can we learn how much force is required to move the reciprocating parts of an engine at the beginning of the stroke?*

Answer. This can be shown if we will imagine that the whole weight of the reciprocating parts is concentrated at the center of the crank-pin. When the crank is revolving and is at the front dead-point, as shown in fig. 86, the tendency of the weight concentrated about the center of the pin *F* would be to move in a straight line, *F w*, at right angles to the center line, *F S*, of the crank, as is shown by the way that water flies from a rapidly revolving grindstone, or sand from a carriage-wheel. This tendency to move in the direction *F w* is resisted by the crank *F S*, which, as it revolves, pulls the weight toward the center, *S*, of the shaft. This pull is called the centripetal force, which is equal to the centrifugal force, and is the same as that exerted on a string when a stone or other heavy object attached to it is whirled around. Now, if the weight was concentrated at the center of the cross-head pin *E*, fig. 81, and it was connected to the crank-pin *F* by a rod, as it is in a steam-engine, just as much force would be required to pull the weight toward the path of the crank-pin as would be needed if their weight were concentrated at *F*. Consequently, if we ascertain the centrifugal force which a weight equal to that of the reciprocating parts of an engine would exert on the crank when it is at a dead-point, we will know the force required to move these parts in a horizontal direction at the beginning of the stroke.

QUESTION 158. *How is the centrifugal force of a revolving body calculated?*

Answer. MULTIPLY THE WEIGHT OF THE REVOLVING BODY IN POUNDS, THE SQUARE OF THE NUMBER OF REVOLUTIONS PER MINUTE, THE RADIUS OR DISTANCE IN FEET FROM THE CENTER OF MOTION, AND .00034 TOGETHER, AND THE PRODUCT WILL BE THE CENTRIFUGAL FORCE.

QUESTION 159. *How can we ascertain how much force is required to accelerate the piston at any point after the crank has passed beyond the dead-point?*

Answer. To explain this it will be supposed that the crank is in the position, *F S*, shown in fig. 87. The mass, whose

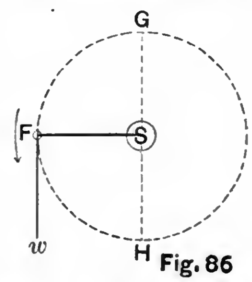


Fig. 86

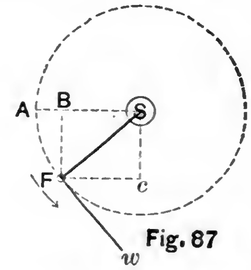


Fig. 87

weight it will again be supposed is concentrated at the center, *F*, of the crank-pin, would then, if left to itself, move in a direction, indicated by *F w*, at right angles to the crank *F S*. The centrifugal force again pulls *F* away from the center *S* and acts in the direction of *F S*. It will be plain that it is only that portion of the centrifugal force which acts horizontally that accelerates or pulls the reciprocating parts in that direction. Therefore, if *F S* is equal to the centrifugal force by drawing a parallelogram of forces, *B S c F*, with *F S* for the diagonal, and the sides *B S* and *F c* horizontal, and *B F* and *S c* perpendicular, then by the principles already explained *B S* and *F c* will represent the horizontal component or the horizontal pull exerted by the centrifugal force acting on the crank when it is in the position shown in fig. 87. Similar diagrams will show the horizontal pull of the centrifugal force for any position of the crank.*

QUESTION 160. *What would be the centrifugal force of the reciprocating parts of a locomotive which weigh 550 lbs., if it has driving-wheels 5 ft. in diameter, cylinders with 2 ft. stroke, and is running 50 miles an hour?*

Answer. By a simple calculation it will be found that at 50 miles an hour wheels 5 ft. in diameter would make 280 turns in a minute. By the rule given in answer to question 158 we would have: $550 \times 280^2 \times 1 \times .00034 = 14{,}660$ lbs.

QUESTION 161. *How can the pressure required to accelerate the piston be shown by a diagram?*

Answer. It has been explained that the pressure required at the beginning of the stroke will be equal to the centrifugal force of the weight of the reciprocating parts, if it was concentrated at the centre of the crank-pin. Horizontal components of the centrifugal force for different positions of the crank can be ascertained by diagrams similar to fig. 87. Having done this, a line, *A E*, fig. 88, may be laid off equal to the stroke of the

* In this explanation no account has been taken of the effect of the angularity of the connecting-rod, which has some, although not a very great influence on the centrifugal action at the crank-pin.

piston, and a perpendicular, $A\ b$, can be drawn from the extremity A, whose length is equal to the centrifugal force. From B at a distance $A\ B$=to $A\ B$, of fig. 87, a perpendicular $B\ d$ is drawn equal to the horizontal component, $F\ c$, of the centrifugal force, as shown in fig. 87. Other lines, as $C\ e$, may be drawn representing the action of the centrifugal force when the crank and piston are in other positions. If, now, a line, $b\ d\ e\ D$, is drawn through the extremities of the perpendiculars, it will be found to be a straight line, which will intersect the center D of the line $A\ E$ representing the stroke ; so that to make a diagram of this kind, all we need do is to calculate the centrifugal force and represent it by a perpendicular $A\ b$ at the end of a line representing the stroke, and then draw a straight line through its extremity b and a point D in the middle of the line $A\ E$.

QUESTION 162. *Is the power required to accelerate the piston in moving from the beginning to the middle of the stroke lost?*

Answer. No ; the power represented by the momentum of the reciprocating parts is communicated by the connecting-rod to the crank-pin after the piston has passed the middle of its stroke. It has been explained that the ***horizontal*** movement of the crank-pin is accelerated during the first quarter of its revolution, and is retarded during the second. Consequently, during the latter period it resists the accelerated motion or momentum of the reciprocating parts, which therefore press against it, and thus do work.

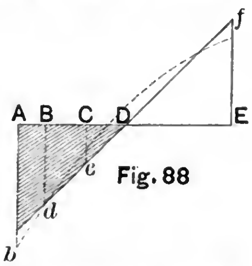


Fig. 88

QUESTION 163. *How may the effect of the momentum of the reciprocating parts be shown in the diagram?*

Answer. During the first half of the stroke, as has been explained, pressure must be exerted against the piston to start the reciprocating parts from a state of rest, and then accelerate their motion up to a point about the middle of the stroke. After that the momentum of these parts exerts a pressure against the crank-pin.

QUESTION 164. *How does the diagram show the momentum of the reciprocating parts?*

Answer. In fig. 88 the vertical distance of the diagonal line $b\ D$ from the horizontal line $A\ E$ represents the pressure which must be exerted to start and accelerate the reciprocating parts. After the piston has reached its maximum velocity near the middle of the stroke the motion of these parts is retarded by the crank-pin, and they consequently press against it. During the first half of the stroke these parts resist acceleration, and during the latter part they resist retardation. Or, in plainer language, in the one case they hold back, and in the other they push the crank ahead. The forces exerted during the two portions of the stroke are of opposite kinds. For that reason the force of momentum of the reciprocating parts is laid off on the opposite side of the line $A\ E$. As the momentum of a moving body is just equal to the force required to produce the motion, if there is no less energy from friction or other causes, the unshaded portion $D\ f\ E$ of the diagram above the line $A\ E$ represents the pressure which the reciprocating parts exert against the crank-pin, and is just equal to $b\ A\ D$. This can be proved by constructing parallelograms of force for the last half in the same way as was explained for the first half. It would thus be found that the horizontal components of the centrifugal force of the reciprocating parts in the different positions of the crank are the same for the last half as they are for the first half of the stroke, if the effect of the angularity of the connecting-rod is not taken into consideration.

QUESTION 165. *What influence does the angularity of the connecting-rod have on the pressure required to accelerate and retard the reciprocating parts?*

Answer. It has been shown from fig. 81 that the rate of acceleration of the piston during the backward stroke is greater than it is for the forward stroke, and the rate of retardation is greater for the forward stroke than for its backward movement. Consequently, if the effect of the connecting-rod is taken into account the pressure represented by $A\ h$ in fig. 88 would be somewhat increased, and that shown by $f\ E$ would be diminished.

The effect of the connecting-rod in thus increasing and diminishing the pressure required to accelerate and retard the reciprocating parts at the two ends of the stroke is equal to the proportion which the length of the crank bears to the connecting-rod. That is, in fig. 81 the crank is $\frac{1}{5}$ the length of the rod, so that $\frac{1}{5}$ must be added to the centrifugal force, which is equal to the pressure required to accelerate the parts when the piston is at the front end of the cylinder, and $\frac{1}{5}$ must be deducted when the piston is at the back end. The line $b\ D\ f$, fig. 88, will then be curved as shown by the dotted line.*

QUESTION 166. *What will be the effect of counterbalancing the reciprocating parts by putting a counterweight opposite to the crank?*

Answer. The effect of a counterweight can be shown if we had an engine with a double crank, as shown in fig. 89, and two cylinders, A and B, on opposite sides of the cranks. If only one of the cylinders, A, had steam admitted to it, obviously the pressure on the piston must be sufficient to overcome its own inertia and that of the piston, B, besides. If the weight of the reciprocating parts in figs. 81–84 was concentrated about the crank-pin F, in the form of a revolving counterweight, then if the crank was revolving at a nearly uniform velocity, the counterweight would impart some of its momentum to the reciprocating parts while they are being accelerated, and some of their energy would be absorbed by the counterweight while they are being retarded. The counterweight would thus act as a fly-wheel, and would absorb and give out energy to and from the reciprocating parts. But it should be observed that when the counterweight is passing the dead-points it has a vertical velocity equal to that of the circumferential velocity of the crank. The reciprocating parts then have no movement, consequently such a counterweight causes a vertical disturbance in the action of the engine, which will be discussed further in a chapter relating to the balancing of locomotives.

CHAPTER IX.

THE LOCOMOTIVE BOILER.

QUESTION 167. *What are the principal parts or "organs" of a locomotive boiler?*

Answer. 1. A fire-place, or, as it is called, a *fire-box*, A (fig. 90), which is surrounded with water.

2. A cylindrical part, $C\ C$, attached to the fire-box at one end and to a chamber, B, called the *smoke-box*, at the other.

3. The tubes or flues $a\ a'$, which connect the fire-box with the smoke-box and pass through the cylindrical part of the boiler and are surrounded with water.

4. The smoke-stack or chimney D.

QUESTION 168. *What is each of these parts or organs for, and of what do they consist?*

Answer. The fire-box A furnishes the room for burning the fuel, and consists of an inner and outer shell, b and c, made of boiler plate, with the space between the two filled with water ; a grate, G, formed of iron bars, with spaces between them for admitting air for the combustion of the fuel, which is placed on the top of them ; a door, E, called the *fire-box* or *furnace-door*, for supplying the grate with fuel ; a receptacle, $E\ E$, below the grate, to collect ashes, and therefore called the *ash-pan*, which is supplied with suitable dampers for admitting or excluding the air from the fire.

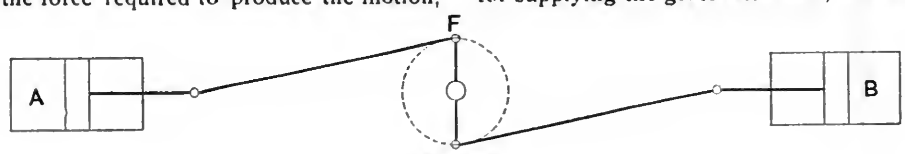


Fig. 89

The cylindrical part $C\ C$, or *waist* of the boiler, as it is sometimes called, contains the greater part of the water to be heated.

The smoke and products of combustion are conducted from the fire-box at the back end to the smoke-box at the front end by means of the flues or tubes, $a\ a'$, which are usually about 2 in. in diameter and from 10 to 12 ft. long. These tubes are surrounded with water and are made of small diameter so as to sub-divide the smoke into many small streams and thus expose it to a large radiating surface through which the heat is conducted to the water.

The chimney or smoke-stack serves partly for removing into

* The proof of this cannot be given here, but it is fully discussed in Arthur Riggs's "Practical Treatise on the Steam-Engine," in George V. Holmes's book on the same subject, and in "A Treatise on the Richards's Steam-Engine Indicator," by Charles T. Porter.

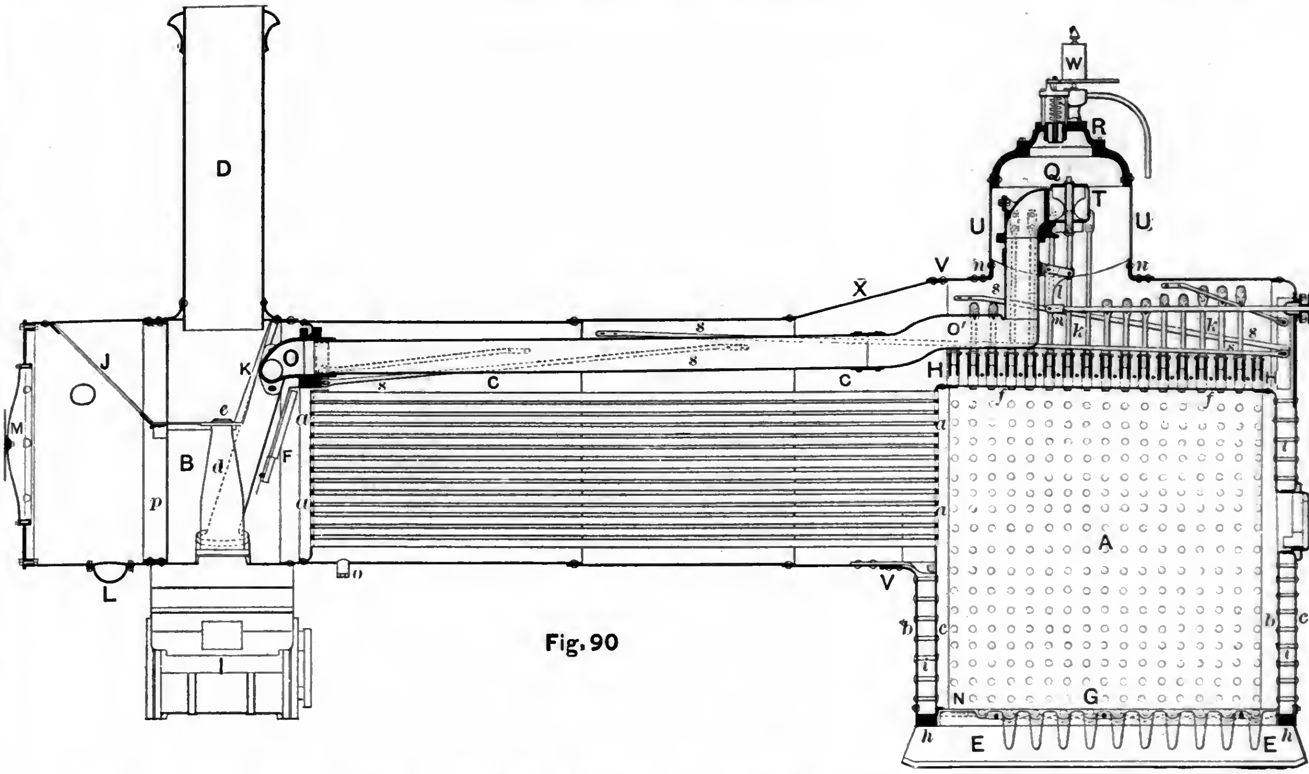


Fig. 90

the open air the smoke which passes through the flues, and partly for producing a strong draft of air, which is indispensably necessary for the rapid combustion of the fuel, and in some cases for arresting and extinguishing the sparks from the fire.

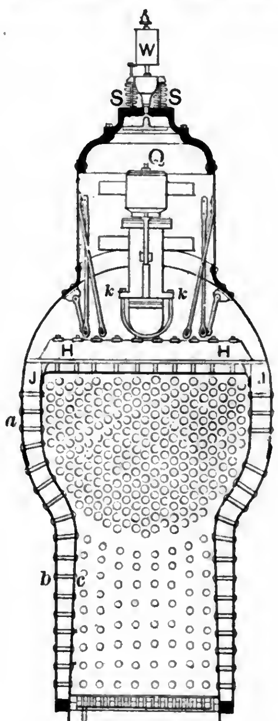


Fig. 91

QUESTION 169. *How is the draft produced in locomotive boilers?*

Answer. By conducting the exhaust steam through one or more pipes (*d*, fig. 90) from the cylinders to the smoke-box and allowing it to escape up the smoke-stack from an aperture or apertures, *f*, called an *exhaust-nozzle*. The strong current of steam thus produced in the chimney produces a vacuum in the smoke-box, by which the smoke is sucked into it with great power and forced up the chimney into the open air.

QUESTION 170. *How does the quantity of steam generated in locomotive boilers in a given time compare with that generated in the boilers of stationary and marine engines?*

Answer. Locomotive engine boilers must produce much more steam in a given time in proportion to their size than is required of the boilers of any other class of engines (excepting, perhaps, those of steam fire-engines), because the space which locomotive boilers can occupy and also their weight is limited.

QUESTION 171. *How is their steam-generating capacity increased above that of marine and stationary boilers?*

Answer. By creating a very strong draft of air through the fire and then passing the smoke and heated air through the tubes. By this means the smoke and hot air are divided into many small streams or currents, which are exposed to the inside surface of the tubes, and the heat is thus imparted to the water which surrounds the tubes.

QUESTION 172. *How is the action of the exhaust steam in producing a draft in the chimney explained?*

Answer. The exhaust steam escapes from the cylinders through contracted openings or exhaust-nozzles, *e*,* which point directly up the center of the chimney. The exhaust steam escapes from this orifice with great velocity, and expands as it rises, so that it fills the chimney *D*. It thus acts somewhat like

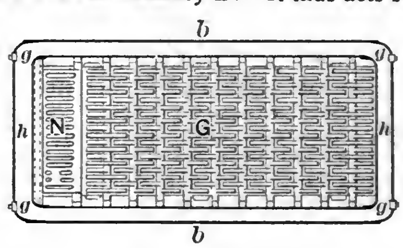


Fig. 92

a plunger or piston forced violently up the chimney, and pushes up the air above it, and, owing to the friction of the particles of air, carries that which surrounds it along with it. They finally escape into the open air, thus leaving a partial vacuum behind in the smoke-box. The external pressure of the atmosphere then forces in air through any and every opening in the smoke-box, to take the place of that already drawn out or exhausted from it. As the only inlet is through the tubes, to which the gases of combustion have free access from the fire-box, and as the external air can only pass through the fire-grate, and through the burning fuel, to reach the fire-box, there is a constant draft of air through the grate as long as the waste steam escapes from the blast-pipe and up the chimney. It is thus that, within certain limits, the more the steam that is required, the more the steam that is produced; for all the steam used in the engine draws in the air in its final escape, to excite the fire

* The term *blast-orifice* is also often used to designate these parts of locomotives.

to generate more steam.* Sometimes one blast-orifice is used for each cylinder; in other cases the exhaust steam from each cylinder escapes through the same orifice.

QUESTION 173. *How much water is it necessary to evaporate in order to furnish the steam required to run an ordinary train at its usual speed?*

Answer. An ordinary "American" locomotive, weighing 80,000 lbs. and with cylinders of 18-in. diameter and 24-in. stroke, will evaporate from 7,500 to 15,000 lbs. of water per hour.

QUESTION 174. *How much water will a pound of coal evaporate in ordinary practice?*

Answer. The quantity of water which is converted into steam by a pound of coal varies very materially with the quality of the coal and the construction and condition of the boiler; but from 6 to 8 lbs. of water per pound of coal is about the average performance of ordinary locomotives. It is, therefore, necessary at times to burn 2,500 lbs. of coal per hour in order to generate the quantity of steam required by such an engine.

QUESTION 175. *How large a grate is needed to burn this quantity of coal?*

Answer. The maximum rate of combustion may be taken at about 125 lbs. of coal on each square foot of grate surface per hour, so that to burn 2,500 lbs. we need a grate with about 20 square feet of surface.

QUESTION 176. *How much heating surface is needed for a given size of grate?*

Answer. In common practice about 50 to 75 square feet of heating surface are given for each square foot of grate. There are, however, no reasons for the proportions of either grate or heating surface which are given, excepting that it has been found that they give good results in ordinary working. The proportion of grate to heating surface is governed to a very great extent by the kind of fuel used. Anthracite coal and the poorer qualities of fuel require larger grates than good bituminous coal or wood. It is, however, quite certain that the larger a boiler is, and the greater its heating surface in proportion to the steam it must generate, other things being equal, the more economical will it be in its consumption of fuel, or, in other words, the more water will it evaporate per pound of coal.

QUESTION 177. *Why is it necessary to use small tubes or flues in order to have the required amount of heating surface?*

Answer. Because there is a great deal more surface in a small tube of a given length, in proportion to the space it occupies, than in a large one. Thus a tube 2 in. in diameter and 12 ft. long has 6.28 square feet of surface, and one 4 in. in diameter has 12.56 square inches, or just *double* the quantity. But the 4-in. tube occupies *four times* as much space as the other, as it is twice as high and twice as wide. Therefore, in proportion to the space it occupies, the tube which is 2 in. in diameter has twice as much surface as the larger one. If we compare a 2-in. with an 8-in. tube, we will find that the former has *four* times as much surface, in proportion to its size, as the 8-in. tube. As the size and weight of locomotive boilers are limited, it is therefore necessary, in order to get the requisite heating surface in the space to which we are confined, to use tubes of small diameter.

Small tubes also have the advantage that they may be made of thinner material, and yet have the same strength to resist a bursting pressure from within, or a collapsing pressure from without, as larger tubes made of thicker metal. The advantage of thin tubes is, that the heat inside of them is conducted to the water outside more rapidly than it would be through thicker metal, which is important when combustion is as rapid as it is in locomotive boilers.

The reason tubes of smaller diameter than 2 in. are not ordinarily used is because they are then liable to become stopped up with cinders and pieces of unconsumed fuel.

QUESTION 178. *How is the fire-box of a locomotive constructed?*

Answer. It usually consists of a rectangular box (*A*, figs. 90, 91, and 92) about 3 ft. wide † and, for the size of engine we have selected as an example, about 6 or 6½ ft. long inside. This box is composed of either iron or steel plates, *c c*,‡ which, excepting on the front side, are from $\frac{5}{16}$ to $\frac{3}{8}$ in. thick. It is called the *inside shell* of the fire-box, and is surrounded by an outside shell, *b b*, of either iron or steel plates, of about the same thickness as those composing the inside, and, as already explained, is so much larger than the inside that there is a space, called the *water-space*, from 2½ to 4½ in. wide, on all the sides of the fire-box between the inner and outer plates.

The top, *f f*, of the inside shell, which is called the *crown-sheet* or *crown-plate*, is usually flat, whereas the outside shell is generally arched, as shown in fig. 91. To the front plate, *a a*, of the inside shell the tubes *a a'*, *a a'* are attached. For this reason its thickness is usually made greater than that of the other plates, and is usually from $\frac{5}{8}$ to $\frac{3}{4}$ in. The edges of one of the plates at each corner of the fire-box, where they are united together, as shown at *g g* in fig. 92, are bent at right angles, and the other is fastened to it with rivets, not shown in the engraving, from $\frac{5}{8}$ to $\frac{3}{4}$ in. in diameter.

The inside and the outside shells of the fire-box are united to each other by a wrought-iron bar or *ring*, *h h*, called a *mud-ring*, which completely surrounds the inner shell and closes the water-space between the two shells. This bar is bent and welded to the proper form to extend around the bottom of the inside fire-box, and it is riveted to both shells. The water in the water-space is in free communication with the rest of the water in the boiler; and thus the flat sides of the respective

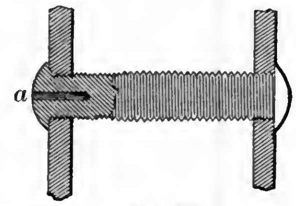


Fig. 93

shells of the fire-box are exposed to the full pressure of the steam, which tends to burst the outside shell and collapse the inside one. These flat sides, by themselves, would be unable to resist the strain upon them, but as the strain upon the respective fire-boxes is in opposite directions, and necessarily equal for equal areas of surface, tie-bolts, *i i*, or, as they are called, *stay-bolts*, which are from $\frac{3}{4}$ to 1 in. in diameter, are screwed through the plates at frequent intervals, usually from 4 to 4½ in. apart, so as to connect the inner and the outer plates of the fire-box securely together, the ends of the stay-bolts being also riveted or spread out by hammering so as still further to increase their holding power. These bolts, owing to the expansion and contraction of the boiler and other strains to which they are subjected, very frequently break, and if they are made of solid bars of metal there is no way of discovering with certainty whether they are in good condition or not without taking the boiler to pieces. They should therefore be made of the best quality of wrought iron, brass, or copper, and should be made tubular or have a hole drilled into one end, as shown at *a*, fig. 93, and extending into the bolt a distance greater than the thickness of the plate into which it is screwed, so that if the bolt breaks the water will escape at the fracture into the hole, and the leak will thus indicate the defect and danger. The latter is much greater from this cause than is usually supposed, and it is not unusual to find in taking a boiler to pieces that a large number of the stay-bolts are broken. Experience shows, too, that when stay-bolts break the fracture nearly always occurs next to the outside plate, so that if holes are drilled in the outer ends of the bolts they will, in nearly all cases, show when a bolt is broken.

QUESTION 179. *How can the strain on the flat surface of a boiler between the stay-bolts be calculated?*

Answer. BY MULTIPLYING THE AREA IN INCHES BETWEEN ADJACENT STAY-BOLTS BY THE PRESSURE. The reason for this is, that each stay-bolt must sustain the pressure on a part of the

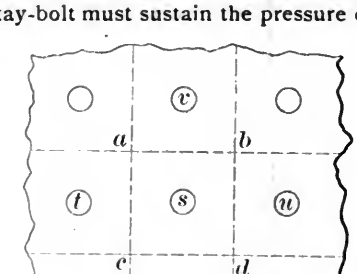


Fig. 94

plate to which it is attached. Thus in fig. 94 it is plain that the bolt *s* must sustain the pressure on one-half of that part of the plate between it and the bolts *v, t, w, u*, around it, or the pressure on the square *a b d c*, whose sides are equal to the distance (4 in.) between the centers of the bolts. With a pressure of 150 lbs. per square inch, the calculation would therefore be: $4 \times 4 \times 150 = 2{,}400$ lbs. on each bolt.

* Colburn's Locomotive Engineering.

† The width is dependent upon the distance between the rails, or *gauge* of the road, as it is called. The above size is for a 4 ft. 8½ in. gauge.

‡ The inside plates are sometimes made of copper.

Stay-bolts should never be subjected to a strain of more than one-tenth or one-twelfth of their breaking strength.

QUESTION 180. *How do stay-bolts often fail without breaking?*

Answer. By tearing or *stripping* the thread of the bolt, or that in the plate, but oftener perhaps by the stretching of the plates between the holes. With a heavy pressure, the tendency of the plates between the holes, especially if they are heated very hot, is to "bulge" outward and thus stretch the hole in every direction until it is so large that the bolt is drawn out without much injury to the screw-thread.

QUESTION 181. *How is the flat-top or crown-sheet strengthened?*

Answer. Usually the crown-sheet is strengthened by a series of iron bars (*H H*, figs. 90 and 91), called *crown-bars*, placed on edge, and of considerable depth, which are firmly fastened to it by rivets or bolts. The crown-sheet can therefore only be crushed downward by bending these bars, which are of great strength. They usually extend crosswise of the length of the fire-box, but are sometimes placed lengthwise. These bars

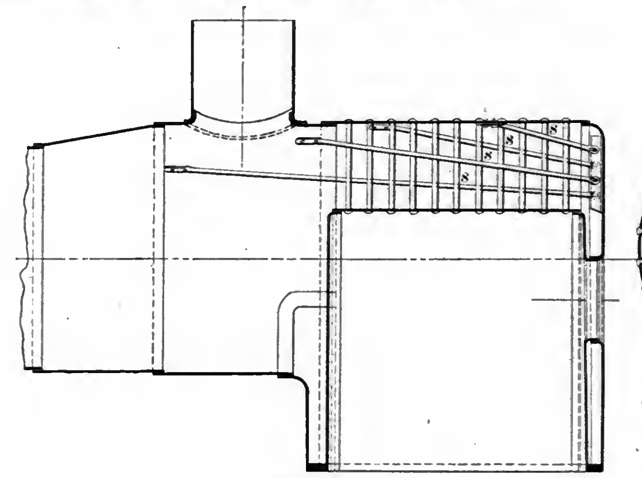


Fig. 95

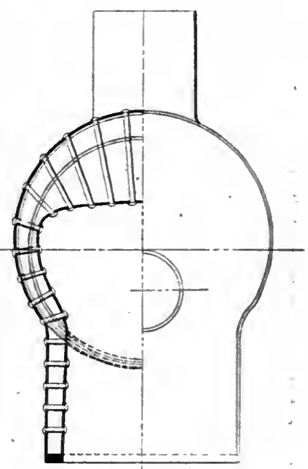


Fig. 96

bear on the fire-box only at each end, as shown in fig. 91, and are usually made with projections, *j j*, which rest on the edges of the side plates. Iron rings or washers are interposed between the plate and the bars at the points where the bolts or rivets which secure the rivets pass through. This permits the

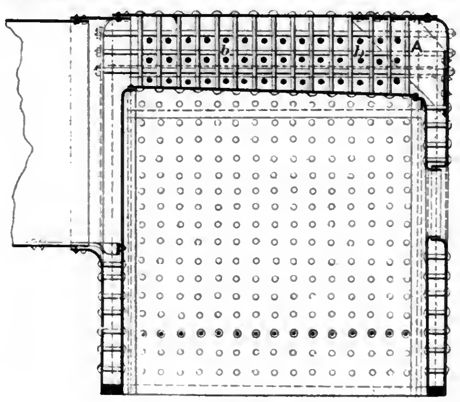


Fig. 97

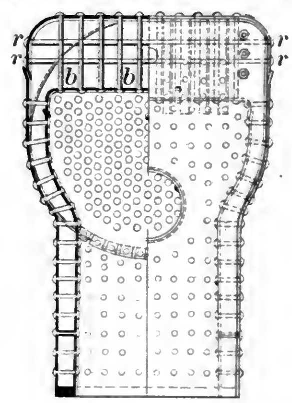


Fig. 98

water to circulate under the bars, and prevents the crown-sheet from being burned or overheated, as it would be if the water were excluded from the whole under surface of the crown-bars.* The crown-bars are also attached to the outer shell and the dome by *braces*, *k k*.

Crown-sheets are sometimes supported by stay-bolts, which are screwed into it and the outer shell of the boiler, as shown in figs. 95 and 96. A difficulty with this form of construction is that to resist the strains produced by the steam pressure on the crown-sheet the bolts should be placed at right angles to its surface, and to resist the pressure against the inner side of the shell of the boiler they should be radial to its cylindrical form. As it is impossible to locate them so as to be both radial to the shell and at right angles to the crown-sheet, all that can be done is to make as close an approximation to each position as is possible. Under these conditions it is difficult to know how much pressure the stay-bolts bear, and consequently the strains to which they are subjected are liable to be excessive.

* Colburn's Locomotive Engineering.

QUESTION 182. *Is there any form of construction which obviates the difficulty of staying crown-sheets which has been pointed out?*

Answer. Yes. In what is known as the Belpaire fire-box both the crown-sheet and the shell of the boiler over it are made flat, as shown in figs. 97 and 98, which show longitudinal and transverse sections of this form of fire-box. These plates are stayed with screw-bolts, *b*, *b*, *b*, at right angles to the plates. The sides, which are also flat, are stayed with rods, *r r*, *r r*, which pass through both the sides.

QUESTION 183. *How are the ends or heads of boilers strengthened?*

Answer. Usually diagonal stays or braces, *s s s*, figs. 90 and 95, are arranged with one end attached to the end or head of the boiler, and the other is fastened to its outside shell.

QUESTION 184. *What precaution should be taken in the design and construction of stays or braces like those which are used for strengthening the ends or heads of boilers and supporting the crown-bars?*

Answer. Great care should be taken to make the parts by which the stays are fastened as strong as the main part of the bar which forms the brace. The principle that the greatest strength of any part of a structure is only that of its weakest part applies with especial force to boiler-stays. Often the grossest carelessness and ignorance is shown in designing and constructing these parts. The eyes and the pins or keys by which they are fastened are often made so that they are much weaker than the body of the bar, and the riveted attachments to the boiler-plates often have only a small percentage of the strength of the main part of the brace or stay.

QUESTION 185. *What other method of staying boiler-heads is sometimes used?*

Answer. What are called "*gusset stays*" are used a great deal in European locomotives. These consist of triangular pieces of boiler-plate *A*, figs. 99 and 100, which are fastened to the boiler-head *B* and to the shell *D* by angle-irons *C* and *C'*, which are riveted to the head and to the shell. The plate *A* is placed between the angle-irons with rivets through all three, as shown in fig. 100. Stays of this kind are often used for Belpaire fire-boxes, an example of which is shown in fig. 97.

QUESTION 186. *How are the grates constructed?*

Answer. They are generally made of cast-iron bars, and for burning coal are usually arranged so that the fire can be shaken by moving the bars. For burning anthracite coal, the grates are

sometimes made of wrought-iron tubes, through which a current of water circulates to prevent them from being overheated.

QUESTION 187. *How are cinders and burning coals which fall through the grate prevented from falling upon the road?*

Answer. By attaching a sheet-iron receptacle or ash-pan (*E E*, figs. 90 and 91), as it is called, under the grate, which is thus completely enclosed from the outside air. As it is often important when the engine is standing still to prevent any access of air to the fire-box, the ash-pan is made to fit tightly to the fire-box, so that air can be excluded from the grate. Suitable doors, or *dampers*, as they are called, are placed in front and behind, and sometimes on the sides, which can be opened or closed to admit or shut out air as may be needed.

QUESTION 188. *How are the tubes or flues of a locomotive arranged?*

Answer. They are fastened into accurately drilled holes in a plate called a tube-plate or tube-sheet (*a*, *a*, figs. 90 and 91), which forms the front of the fire-box and in similar holes in another plate (*a'*, *a'*, fig. 90), which forms the front end of the cylindrical part of the boiler. They thus connect the fire-box with the smoke-box. The tubes are arranged so that each one will have a space of from $\frac{5}{8}$ to $\frac{7}{8}$ in. between it and those next to it. The position of the holes for the tubes in relation to each other is determined by describing from the center of one tube (*o*, fig. 101) a circle with a radius, *o k*, equal to the sum of the outside diameter of the tubes and the distance which they are intended to be apart, and then subdividing this circle with the radius into six parts, *k r*, *r s*, *s l*, *l g*, *g p*, and *p k*. Each point of subdivision and also the center, *o*, of the circle will be the center of a tube. By laying them off from these centers it will be found that the distances *a b*, *c d* between adjoining tubes will be the same between all of them. By describing circles from the centers of the outside tubes and sub-dividing the circles as before the position of other tubes will be determined around those first laid down. This can, of course, be carried out indefinitely.

A difference in the arrangement of the tubes will be observed if, when we subdivide the first circle shown in fig. 100, instead of commencing from the intersection of a vertical line we begin from a horizontal line, *h i*, as shown in fig. 102. In the former case the tubes are said to be in *vertical rows*, and in the latter in *horizontal rows*. It is apparent from the figures and as shown by the arrows that the water can circulate in ascending currents more freely when tubes are arranged in vertical rows than when they are arranged horizontally.

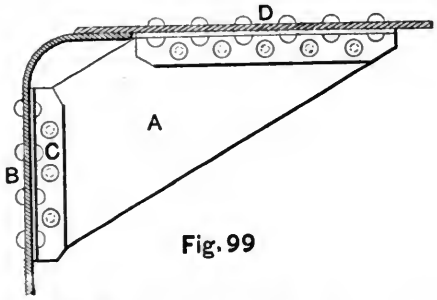


Fig. 99

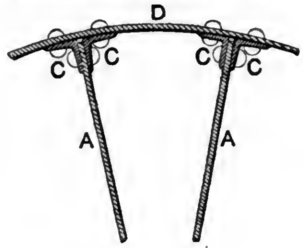


Fig. 100

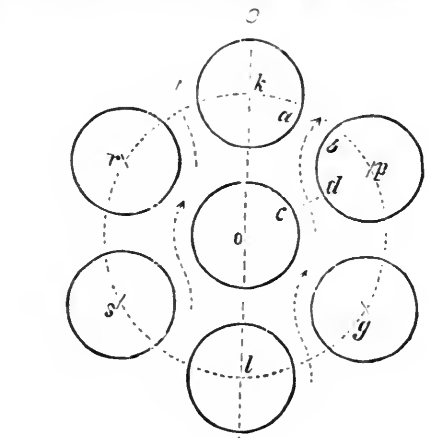


Fig. 101.

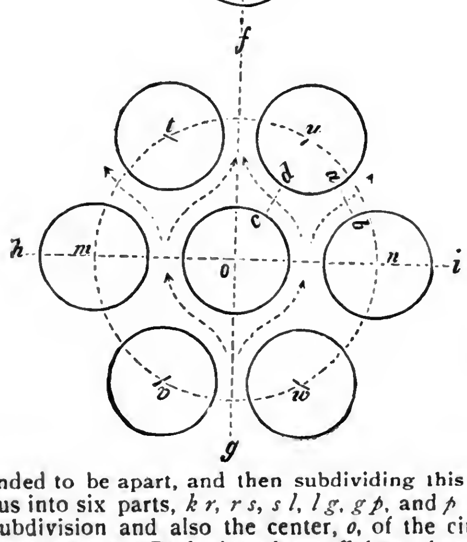


Fig. 102.

QUESTION 189. *How are the tubes fastened and made water-tight in the tube-sheets?*

Answer. They are inserted into the holes drilled to receive them, and the ends are allowed to project about a quarter of an inch beyond the tube-sheets. A number of different kinds of tools have been devised for expanding tubes in the tube-plates and making a shoulder on each side of the plate so as to keep the tubes water-tight. Figs. 103–107 represent Prosser's expander. When this is used a tapered plug, fig. 103, is first driven into the tube to expand it so that it will fill the hole. Fig. 104 represents a perspective view and figs 105 and 106 side and end elevations of the "spring expander." This may be called an expanding plug composed of eight or more sector-shaped pieces, *a*, *b*, *c*, *d*, *e*, *f*, *g*, and *h*, which are held together by an open steel spring-ring or clasp *s*, which embraces them as shown in figs. 104–106. The inner portion of the sectors is cut away so as to leave a hole, *C*, figs. 104 and 105, in the middle of the plug. When the sections are drawn together the plug is inserted into the mouth of the tube, and a tapered plug is then driven into the hole, *C*. The spring ring or clasp *s* permits the sectors to separate when the tapered plug is driven into the opening in the center of the cluster of sectors. Each of the sectors has a projection, *j*, *k*, *l*, *m*, where it comes in contact with the outer edge of the tube, and another just inside of the tube-plate. These projections form a ridge, *a b c d*, fig. 104, and another, *j k l m*, on the plug. When the tapered plug or mandrel is driven into the central opening the sectors are forced apart, and they thus expand the tube and at the same time

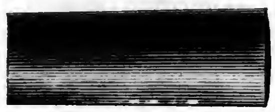


Fig. 103.

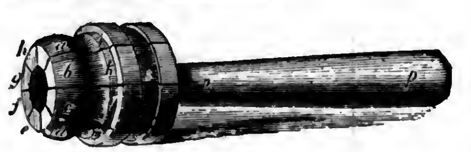


Fig. 104.

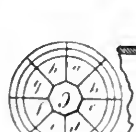


Fig. 105.

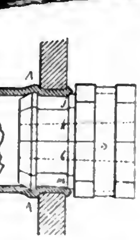


Fig. 106.

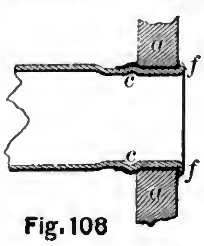


Fig. 108

their projections form a ridge in the tube around the inner and outer edges of the hole in the plate, as shown at *c c*, fig. 108. By slightly turning the expander each time the mandrel is driven in, and repeating the process, the tubes can be made perfectly water-tight. In many cases, after the tubes are expanded with the tool described, the outer edge is turned over still more with what is called a *thumb-tool*, fig. 109, probably from its resemblance in form to a man's thumb. By placing the curved shoulder *a* on the end *f*, fig. 108, of the tube it is turned over, somewhat in the form shown in the engraving, by repeated blows of a hammer on the end of the tool.

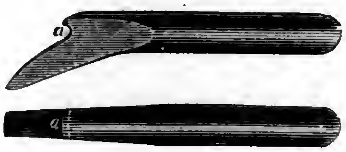


Fig. 109.

Fig. 110 represents Dudgeon's roller expander. This may be described as a hollow plug which has three rollers, which are contained in cavities in the plug in which they can revolve, and in which can also move a short distance radially—that is, from the center of the plug outward. When the expander is inserted into the end of the tube a tapered mandrel, fig. 110, is driven into the central opening, and it then bears against

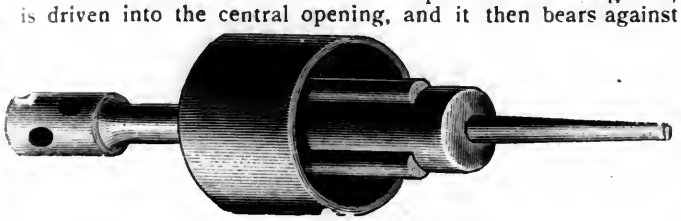


Fig. 110.

the rollers and forces them outward against the tubes. A crank handle is then attached to the end of the mandrel, and it is turned around, which causes the rollers to revolve on their own axes. This causes the hollow plug to revolve around its axis. The two thus have a sort of sun and planet motion in relation to each other. As the rollers bear hard against the tube, the effect is to elongate it circumferentially, and thus enlarge it so as to completely fill the opening in the tube-plate.

There are other forms of tube-expanders, but those described are more generally used than any others.

Copper ferrules, represented by the black shading, *a a*, fig. 108, are also much used now on the outside of locomotive tubes, and it is said that with them the joints can be kept tight much easier than without. By turning over the outside edge of the tube, as shown in fig. 108, it not only protects the copper ferrule, but, as the tubes must act as braces to sustain the pressure of steam in the flat tube-sheets, it gives the joints the requisite strength for resisting such strains.

Cast-iron or steel ferrules, which are made tapered and driven into the mouths of the tubes, as shown in fig. 113, are also used in some cases. These are simply driven into the tube after it has been expanded.

QUESTION 190. *How can the strain on the cylindrical part of a boiler be calculated?*

Answer. BY MULTIPLYING THE DIAMETER IN INCHES BY THE LENGTH IN INCHES AND THE PRODUCT BY THE STEAM PRESSURE PER SQUARE INCH. Thus for a boiler 48 in. in diameter and 10 ft. long with 100 lbs. pressure the calculation would be $48 \times 120 \times 100 = 576{,}000$ lbs.

QUESTION 191. *Why do we multiply the diameter, instead of the circumference, by the length, to get the strain on the cylindrical part?*

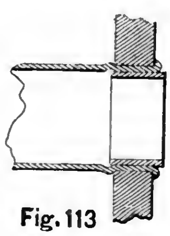


Fig. 113

Answer. The reason for multiplying by the diameter instead of by the circumference is because only a portion of the pressure on the inside surface of the boiler exerts a force to burst the shell at any one point. Thus, supposing the diagram, fig. 114, to represent a section of a boiler, if we have a force acting on the shell in the direction of the line *a b*, at the point *b*, where it is exerted against the shell of the boiler, it would be composed of two forces, one acting in the direction *b e*, and tending to tear the boiler apart on the line *c d*, and the other acting in the direction *f b*, to tear it apart on the line *h g*. It is so with all pressure inside the boiler, excepting that, say *a h*, which acts exactly at right angles to the line of rupture *c d*; it is all composed of two forces, only one of which tends to tear the boiler apart at one point. It is therefore only a part of the pressure on the circumference which tends to burst the boiler at a given place, and that part is equivalent to the pressure on a surface whose width is equal to the diameter and not the circumference.

This may be difficult for those to understand who are not familiar with the principles of what is called the "resolution of forces," which were explained in Chapter VII; but it may be made clear in another way.

Let it be supposed that we have a boiler, *a b*, fig. 115, made in two halves and bolted together at *a* and *b* by flanges. It is evident that if we brought a pressure against the inside of the flanges in the direction of the darts *c* and *d*, such a pressure would not have a tendency to tear apart the bolts *a* and *b*, by which the two halves of the boiler are fastened together. Some distortion of the boiler might, in fact, take place if, for example, we put a jack-screw inside and forced the flanges *a* and *b* outward as indicated by the darts *c d*, without subjecting the bolts to a tensile strain. We see therefore that the forces acting in the direction *c* and *d* have no tendency to tear the bolts at *a* and *b* asunder, but it is only such forces as *e*, *f*, and *g*, which act at

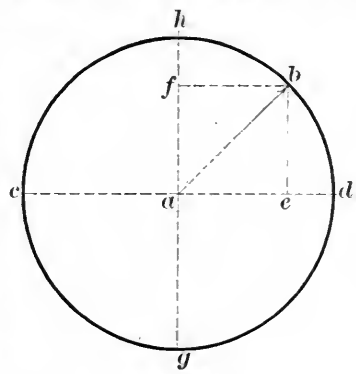


Fig. 114

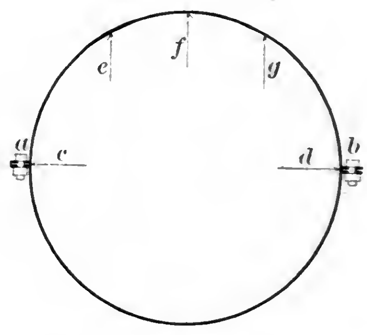


Fig. 115

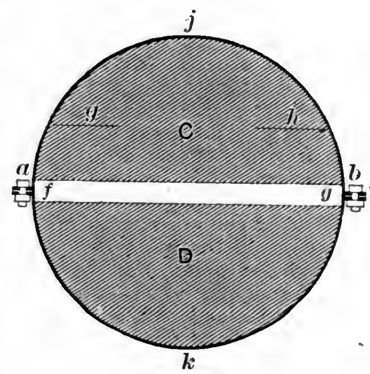


Fig. 116

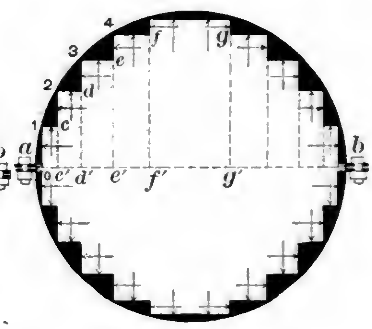


Fig. 117

right angles to the diameter *a b*, that exert a strain on the flanges.

That this force is equivalent to a pressure on a surface with a width equal to the diameter will be apparent if we suppose that we have a boiler, *a b*, fig. 116, and that each half, *C* and *D*, is nearly filled with some substance, say wood or cement, which is fitted so tight that no steam can get between it and the shell of the boiler. It will be apparent that if we admit steam into the space *f g*, the force exerted on the bolts *a* and *b* is that due to the pressure on the surface of the wood or cement exposed to the steam whose width is equal to the diameter of the boiler. It may be said, though, that if this substance were elastic, like india-rubber, the effect of the steam would be different.

But even if it were elastic, the pressure of the steam would be exerted at right angles to the surfaces *f g*, and the pressure on these surfaces would not be increased or diminished if the elastic substance should spread laterally. If it should do so and thus produce pressures in the direction *g* or *h* it would not produce any strain on the bolts *a* and *b*, to tear them apart, but such pressures would have a tendency to rupture the boiler on the line *j k*.

The effect of internal pressure in a boiler may be made clear in still another way. Let it be supposed that we have a cast-iron boiler the inside surface of which is formed as shown in fig. 117—that is, it is serrated or formed like steps, with vertical and horizontal surfaces as shown. It may be assumed, without

leading us into error, that the pressure of the steam is exerted at right angles to these surfaces—that is, that it acts in the direction indicated by the darts. Obviously the pressure which tends to pull apart the bolts *a* and *b* is that represented by the vertical darts, and which acts on the horizontal surfaces, and the total strain which these bolts must resist is equal to the area of these surfaces multiplied by the pressure per square inch. But if we draw vertical lines *c c'*, *d d'*, *e e'*, etc., from the stepped surfaces to the diameter *a b*, it will be apparent that the area of the horizontal stepped surfaces 1 *c*, 2 *d*, 3 *e*, 4 *f*. *f g*, etc., are equal to *o c'*, *c' d'*, *d' e'*, *e' f'*, *f' g'*, etc., and that they are equal in length to the diameter *a b*, so that if we multiply this diameter by the length of the boiler and the pressure per square inch it will give the pressure which is exerted on the horizontal surfaces 1 *c*, 2 *d*, 3 *e*, etc. It may now be imagined that the steps are infinitely small. In that case the internal stepped or notched surface would coincide and be equivalent to a cylinder without such notches. Therefore the reasoning which applies to the one will apply to the other. The effect of the pressure which acts horizontally or in any other direction can be shown in the same way.

The sides of a boiler must therefore be made strong enough to resist the pressure which the steam exerts on a surface the length of which is equal to that of the boiler, and the width equal to its diameter.

QUESTION 192. *What are the metals principally used in boiler construction?*

Answer. Until lately wrought iron has been the principal metal used in the construction of boilers, but it has now, to a very great extent, been superseded by mild steel.

QUESTION 193. *What advantages has mild steel as a material for boilers?*

Answer. Its strength to resist strains of tension and compression is considerably greater than that of iron, thus permitting the use of thinner plates. Its ductility is greater, its structure more homogeneous, and its quality more uniform.

QUESTION 194. *How much strain per square inch is good boiler-plate capable of resisting, and how much is it safe to subject it to?*

Answer. There is great difference in the tensile strength* of rolled iron boiler-plate, but that of good plate will average about 50,000 lbs. per square inch, if the strain is applied in the direction of the "grain" or the fibers of the iron,† and about 10 per cent. less if the strain is applied crosswise of the grain. It has, however, been found by experiment that when a tensile strain is applied to a bar of iron or other material, it is stretched a certain amount in proportion to the length of the bar and to the degree of strain to which it is subjected. If this strain does not exceed about one-fifth of that which would break the bar, it will recover its original length, or will contract after being stretched, when the strain is removed. The greatest strain which any material will bear without being permanently stretched is called its *limit of elasticity*, and so long as this is not exceeded no appreciable permanent elongation or "set" will be given to iron by any number of applications of such strains or loads. If, however, the limit of elasticity is exceeded, the metal will be permanently elongated, and this elongation will be increased by repeated applications of the strain until finally the bar will break. At the same time the character of the metal will be altered by the repeated application of strains greater than its elastic limit, and it will become brittle and less able to resist a sudden strain, and will ultimately break short off. It is therefore unsafe to subject iron, or, in fact, any other material, to strains greater than its elastic limit. This limit for iron boiler-plates may be taken at about one-fifth its breaking, or, as it is called, *ultimate* strength. It should be remembered, however, in this connection, that it often happens that the steam pressure is not the greatest force the boiler must withstand, as sudden or unequal expansion and contraction are probably more destructive, to locomotive boilers especially, than the pressure of the steam.

QUESTION 195. *What is the relative strength of wrought-iron and mild steel plates?*

Answer. Good wrought-iron boiler-plates have a tensile strength of about 50,000 lbs. per square inch, and mild steel about 60,000 lbs.

QUESTION 196. *What are the most important qualities which boiler-plates should possess?*

Answer. The first quality to be sought for in a boiler-plate is strength. This does not necessarily imply the mere power to resist being torn asunder by a dead weight, as in a testing machine, but the quality to withstand, without injury, the many and varying shocks and strains it is exposed to in the boiler-shop and in actual work. Many inferior plates exhibit as great a cohesive strength as those of better quality, their inferiority consisting in their brittleness or shortness, want of "body" or soundness, imperfect manufacture, and uncertain character or quality. Toughness and ductility combined with great tenacity, and also closeness and uniformity of texture and constancy of quality, are the properties and character to be sought for.*

QUESTION 197. *What qualities should boiler-plates and rivets have?*

Answer. All iron plates of the *best* quality should have a longitudinal tenacity of not less than 50,000 lbs. per square inch of section, and an ultimate elongation before breaking of about 12 per cent., and if not exceeding 1 in. in thickness, should bend double along or across the fiber when red hot, and if $\frac{7}{16}$ in. thick and under, they should bend double when cold without fracture.

Good iron plates should bend cold, without fracture, to the following angles :

Thickness of Plate.	Along the Fiber.	Across the Fiber.
¼ inch	90 degrees	55 degrees.
$\frac{5}{16}$ "	80 "	45 "
⅜ "	70 "	35 "
$\frac{7}{16}$ "	55 "	25 "
⅝ "	40 "	20 "
¾ "	30 "	15 "
⅞ "	20 "	10 "
1 "	15 "	7 "

The radius of the corner over which the plates are bent should not exceed half an inch.*

Steel boiler-plates should have a tensile strength of about 60,000 lbs. per square inch, and it should not be less than 50,000 nor more than 70,000 lbs., and when broken under tension the ultimate elongation of a test piece 8 in. in length, after fracture, should be not less than 20 per cent. of the original length. Strips not less than 2 in. broad and 10 in. long, cut from plates *not* exposed to the fire in service, should bear bending cold without fracture until the sides are parallel at a distance from each other of not less than three times the thickness of the plate. Strips taken from plates which, in service, will be exposed to the fire, should be heated, before bending, to a cherry red, then plunged into water of about 80° temperature, and kept there until of the same temperature as the water. They should then stand the same test required for the pieces which are bent cold.

The material of which rivets are made should have a high degree of ductility. A good iron rivet, cold, should bend double without fracture, and its head should flatten out by hammering when hot to about ⅛ in. thick without fracture or fraying at the edge. A hot rivet-shank, when flattened down to a thickness equal to about one-half its diameter, should bear a punch driven through it without fracture at the hole.*

The steel of which rivets are made should always be of the mildest—that is, the most ductile material, because if it is not of this character they are liable to become hard and brittle while being worked and in use.

The resistance of steel rivets to shearing should therefore not be greater than that of iron rivets, or about 50,000 lbs. per square inch of section.

QUESTION 198. *Why should the greatest strength steel plates and rivets not exceed a certain limit?*

Answer. Because steel of a very high tensile strength is usually brittle and liable to fracture, whereas soft ductile steel usually has a comparatively low tensile strength.

QUESTION 199. *How are boiler-plates fastened together?*

Answer. By rivets which are made with a head on one end, and which are inserted red hot in holes, which are drilled or punched in the plates, and another head is then formed by hammering, or by steam, or hydraulic pressure, on the other end of the rivet. The rivets are thus made to fill the holes, and in cooling contract and draw the plates together.

QUESTION 200. *What is the strength of riveted seams compared with that of the solid plate?*

Answer. The strength of a riveted seam depends very much upon the arrangement and proportion of the rivets ; but with the best design and construction, the seams are always weaker than the solid plates, as it is always necessary to cut away a part of the plate for the rivet holes, which weakens the plate in two ways : 1. By lessening the amount of material to resist the

* A force exerted to pull any material apart is called a *tensile strain*, and if exerted to compress it is called a *compressive strain*.

† It should be explained that in the process of manufacturing iron by rolling, the iron is stretched out into fibers in the direction in which it passes between the rolls.

* Wilson's Treatise on Steam Boilers.

strains. 2. By weakening that left between the holes. The first cause of weakness is obvious from an inspection of an ordinary seam, riveted with a single row of rivets, fig. 118. In this we have two plates $7\frac{1}{2}$ in. wide and $\frac{3}{8}$ thick fastened with

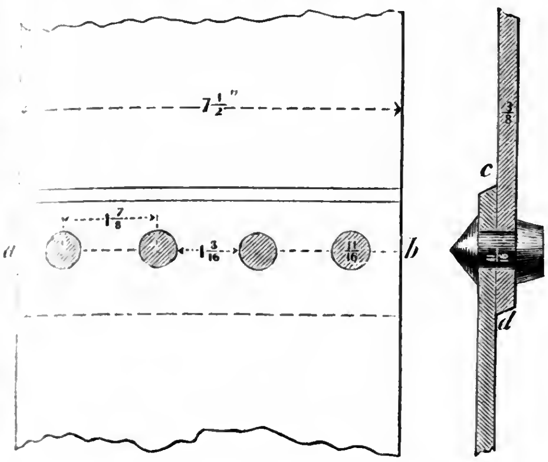


Fig. 118.

four rivets $\frac{11}{16}$ in. in diameter and $1\frac{7}{8}$ in. from center to center. The section of the plate calculated with decimals * would therefore be $.375 \times 7.5 = 2.81$ square inches. A piece $\frac{11}{16}$ in. wide and $\frac{3}{8}$ in. thick would be removed to form each hole, or a sectional area for the whole plate of $.375 \times .6875 \times 4 = 1.03$ square inches, so that the section of the plate would be reduced through the holes $2.81 - 1.03 = 1.78$ square inches. In other words, on the dotted line *a b* it will have only about 63 per cent. of the sectional area of the solid plate.

The second cause of the reduction of strength is owing to the injury sustained by the plates during the process of punching. The knowledge existing regarding this subject is not very satisfactory, although numerous experiments have been made to determine the exact amount of weakening caused by punching plates. It is, however, certain that in many cases the strength of the metal *left* between the holes of boiler-plates is reduced from 10 to 25 per cent. by the process of punching. It is probable, however, that soft ductile metal is injured less than that which is harder and more brittle. Some kinds of steel plates are especially liable to injury from punching. It is also probable that the condition of the punch, and the proportions of the die used with it, have much to do with its effect upon the metal.

QUESTION 201. *How can the injury done to boiler-plates by punching be prevented?*

Answer. It has been shown that the injury to plates from punching is confined to a narrow area around the hole, and that by punching the hole smaller than required and then reaming it or drilling it to the required size the weakened portion of the plate is removed, leaving that portion between the holes equal, or, as has been shown in some experiments,† of greater strength than the original plate. It has also been shown by some experiments that annealing steel plates after punching restores them to their original strength ; but with the mild steel now made there is little need of this precaution, and there is, perhaps, more danger of damaging the plates by careless attempts at annealing than by deterioration of metal in punching.

QUESTION 202. *How may a boiler seam like that shown in fig. 118 break?*

Answer. It may break in three different ways :

1. By a plate tearing between the rivet holes on the line *a b*.
2. By the rivets shearing off.
3. By the plate in front of the rivets crushing, as shown in fig. 119, or splitting the plate at right angles to the seam, as shown in fig. 119*a*.

QUESTION 203. *How can the strength of a boiler seam be calculated at each of these three points?*

Answer. The strength through the rivet holes is calculated by TAKING THE AREA IN SQUARE INCHES OF THE METAL WHICH IS LEFT BETWEEN THE RIVET HOLES, AND MULTIPLYING IT BY THE ULTIMATE STRENGTH OF THE METAL AFTER THE HOLES ARE MADE. Thus, in fig. 118, the area of each of the plates between the rivet holes is 1.78 square inches. As already stated, good iron boiler-plate will break at a strain of about 50,000 lbs. in the direction of its fibers.* The calculation for the strength through the holes would therefore be : $1.78 \times 50{,}000 = 89{,}000$ lbs. If the holes are punched and not afterward reamed or drilled the strength of the plates, as already explained, would

Fig. 119.

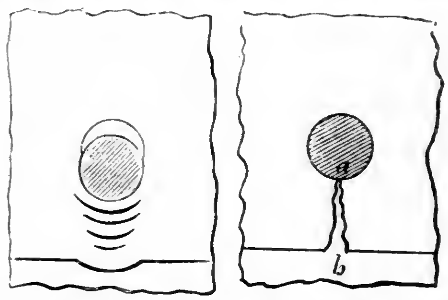


Fig. 119a.

be considerably reduced, and a lower tensile strength must be used in calculating the strength of the seam.

It has also been found by experiment that the strength of rivets to resist shearing is about the same as that of good boiler-plate to resist tearing apart, or 50,000 lbs. per square inch. The strength of the rivets, therefore, is calculated by MULTIPLYING THE AREA IN SQUARE INCHES OF ONE RIVET BY THE NUMBER OF RIVETS, AND THE PRODUCT BY THE STRENGTH OF THE METAL TO RESIST SHEARING. The calculation for fig. 118 would therefore be :

Area of $\frac{11}{16}$ rivet $= .3712 \times 4 \times 50{,}000 = 74{,}240$,

or somewhat less than the strength of the plates through the holes.

The resistance offered by a plate to the crushing strain of a rivet has been found also by experiment to be about 90,000 lbs. per square inch. It can be proved that the area which resists the crushing strain of a rivet in a plate, fig. 118, IS MEASURED BY MULTIPLYING THE DIAMETER OF THE RIVET BY THE THICKNESS OF THE PLATE. The calculation for the strength of this part of the seam will therefore be : diameter of hole $= .6875 \times .375 \times 4 \times 90{,}000 = 92{,}812$.

The strength of the solid plate without any holes in it would be EQUAL TO ITS SECTIONAL AREA MULTIPLIED BY 50,000 LBS., or $7.5 \times .375 \times 50{,}000 = 140{,}625$ lbs. The ultimate strength of our seam would then be as follows :

Rivets	(shearing)	= 72,240 lbs.
Plates through rivet holes	(tearing)	= 89,000 "
Plates in front of rivets	(crushing)	= 92,812 "
Solid plate	(tearing)	= 140,625 "

It will thus be seen that the strength of the weakest part of the above seam, fastened with a single row of rivets, is very little more than half (51.3 per cent.) of that of the solid plates. It will be noticed that the plates between the holes have an excess of strength over the rivets, which is desirable, because the plates are liable to more or less injury from punching.

QUESTION 204. *What are the usual proportions for single-riveted lap seams?*

Answer. The following table gives the usual proportions for such seams :

SINGLE-RIVETED LAP JOINTS.

Iron Plates, Iron Rivets.			Steel Plates, Iron Rivets.		
Thickness of Plates.	Diameter of Rivets.	Pitch of Rivets.	Thickness of Plates.	Diameter of Rivets.	Pitch of Rivets.
$\frac{5}{16}$ inch.	$\frac{11}{16}$ inch.	$1\frac{13}{16}$ inch.	$\frac{5}{16}$ inch.	$\frac{11}{16}$ inch.	$1\frac{9}{16}$ inch.
$\frac{3}{8}$ "	$\frac{3}{4}$ "	$1\frac{7}{8}$ "	$\frac{3}{8}$ "	$\frac{3}{4}$ "	$1\frac{9}{16}$ "
$\frac{7}{16}$ "	$\frac{13}{16}$ "	$1\frac{15}{16}$ "	$\frac{7}{16}$ "	$\frac{13}{16}$ "	$1\frac{11}{16}$ "
$\frac{1}{2}$ "	$\frac{7}{8}$ "	2 "	$\frac{1}{2}$ "	$\frac{7}{8}$ "	$1\frac{11}{16}$ "
$\frac{5}{8}$ "	$\frac{15}{16}$ "	$2\frac{1}{16}$ "	$\frac{5}{8}$ "	$\frac{15}{16}$ "	$1\frac{13}{16}$ "
$\frac{3}{4}$ "	$1\frac{1}{16}$ "	$2\frac{3}{16}$ "	$\frac{3}{4}$ "	$1\frac{1}{16}$ "	$1\frac{7}{8}$ "
$\frac{7}{8}$ "	$1\frac{1}{8}$ "	$2\frac{1}{4}$ "	$\frac{7}{8}$ "	$1\frac{1}{8}$ "	2 "
1 "	$1\frac{1}{4}$ "	$2\frac{5}{16}$ "	1 "	$1\frac{1}{4}$ "	$2\frac{1}{16}$ "

QUESTION 205. *Is the maximum strength of seams the chief aim in designing a boiler?*

Answer. No ; a tight joint is of the first importance, for should leakage occur corrosion may soon alter any carefully calculated proportions of the respective sections in the joint. Indeed, it may be affirmed that in the majority of cases the safety of a boiler depends, in the long run, more upon the tight-

* In the following calculations all the dimensions have for convenience been reduced to decimals.

† See a description of Tensile Tests of Iron and Steel Bars, by Peter D. Bennett, in the Proceedings of the Institution of Mechanical Engineers, for February, 1886.

* Boiler-plates should always be so arranged that the greatest strain will come on them in the direction of their greatest strength, which is parallel with the fibers of the metal.

† This is the diameter of the rivets before being driven ; the holes are usually made $\frac{1}{16}$ in. larger.

ness than the actual strength of the joints, since a large factor of safety is usually allowed.*

QUESTION 206. *How may a single-riveted lap seam be made stronger than that illustrated by fig. 118?*

Answer. The most obvious way of doing this is to increase the *pitch*—that is, the distance from center to center—and the diameters of the rivets, which would leave more metal between the holes, and thus strengthen the seam at its weakest part. But if this is done, it is said that there is difficulty in keeping the seam water-tight, as the plates are then liable to spring apart between the rivets. Another way of increasing its strength is to drill the rivet holes. As already stated, the difference in the strength of the metal left between drilled and punched holes has been shown to be from 10 to 25 per cent. There is also another advantage in drilling the holes for rivets. In punching them, it is necessary to punch each plate separately, and even with the utmost care and skill it is impossible to get

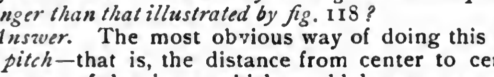


Fig. 120.

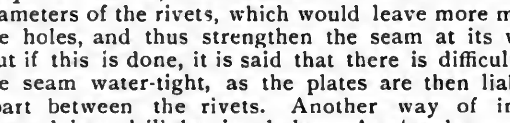


Fig. 121.

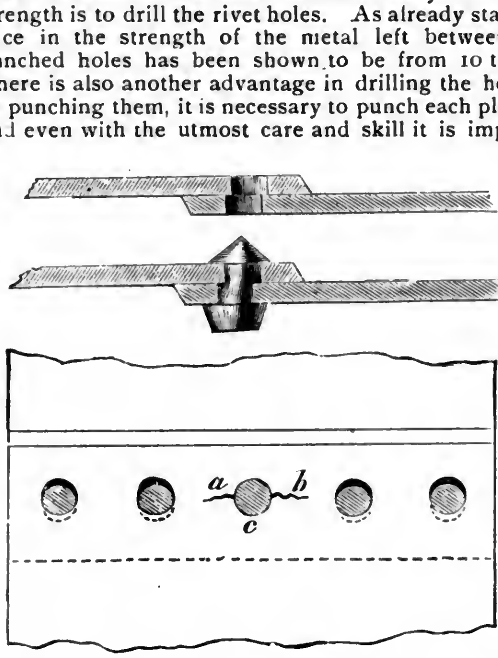


Fig. 122.

the holes to match perfectly. Some of them will overlap each other, as shown in fig. 120, so that when the rivet is set, it will assume somewhat the form shown in fig. 121. There is then danger that those rivets which fill the holes that match each other will be subjected to an undue strain. If, for example, we have five rivet holes, as shown in fig. 122, and only the center ones correspond with each other, then the rivets in all the other holes will assume somewhat the form shown in fig. 121, and therefore the center rivet *c*, in fig. 122, which fits the holes accurately, must take the strain of the other four until they draw up "to a bearing." Under such circumstances, which are not unusual, there will be great danger either of shearing off the rivet *c*, or of starting a fracture in the plates, as indicated by the irregular line *a b*, between the adjoining rivets. It is also obvious that a rivet like the one in fig. 121 will not hold the plates together so well as one which fits more perfectly, as shown in section in fig. 118, and therefore there is more danger of leakage between the plates from badly fitted rivets than from those which fill the holes more perfectly; consequently rivets which fit imperfectly must be placed nearer together than those which are well fitted. It is true that rivets which are set with a riveting machine fill any inaccuracies of the holes more perfectly than those which are set by hand. But even if they are made to fill the holes as shown in fig. 123 they are still not so strong to resist shearing nor so efficient in

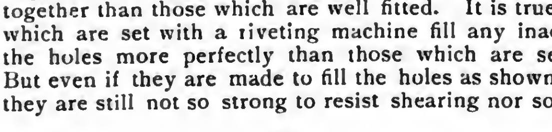
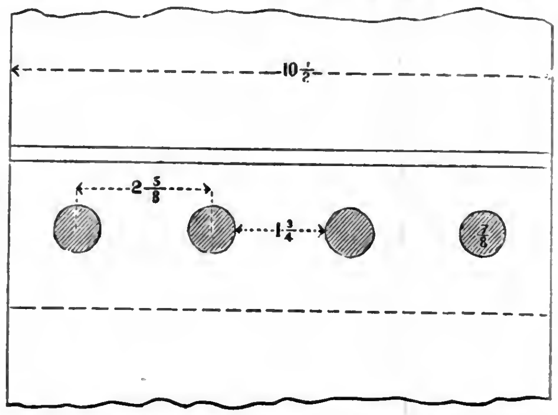


Fig. 123.

holding the plates together as they would be if the holes conformed more perfectly to each other. In drilling the holes, the second plate can be drilled from the holes in the first, so that the holes in each one will correspond with the other perfectly. The rivets will therefore fit more accurately, and consequently can be spaced further apart, and still keep the plates tight, and thus there will be more material between the holes, which is the weakest part of the seam. It has been shown that a rivet $\frac{11}{16}$ in. in diameter has a resistance to shearing of 18,560 lbs. There is therefore no advantage with plates $\frac{3}{8}$ in. thick in spacing such rivets further apart than $1\frac{13}{16}$ from center to center, because the metal of 50,000 lbs. of tensile strength which is left between drilled holes that distance apart would be slightly stronger than the rivets. If therefore the rivets are placed further apart, their diameter must be increased. There is, however, a limit beyond which the diameters of rivets cannot be increased with advantage, because if we increase their diameters, their sectional area to resist shearing is increased in proportion *to the square of the diameter*, whereas the section of metal in the plate to resist crushing is increased only *in proportion to the diameter*. This will be apparent if we compare a rivet $\frac{1}{2}$ in. with one 1 in. in diameter. The first has a sectional area of .1963 in., the other .7854 in., or *four* times that of the first one. Now the area which resists the crushing strain of the rivets is increased only in proportion to their diameters, or is *twice* as much for the one as for the other. If, therefore, we increase the diameters of the rivets, we very soon reach a point at which the plate has less strength to resist crushing than the rivet has to resist shearing. The diameter of rivet which will give just the same resist-

Fig. 124.



ance to both strains varies with the thickness of the plates; with $\frac{3}{8}$-in. plates a $\frac{7}{8}$-in. rivet will have a resistance to shearing of 30,065 lbs. and the plate in front of it a resistance to crushing of 29,530 lbs. A $\frac{7}{8}$-in. rivet is, therefore, the largest size which can be used to advantage in $\frac{3}{8}$-in. plates. If now we were to space such rivets so far apart that the metal left between the holes would have a strength just equal to that of the rivets, we would have the strongest possible seam that can be made with a single row of rivets. This distance would be $1\frac{3}{4}$ in. between the edges of the rivets, or $2\frac{5}{8}$ in. from center to center, as shown in fig. 124. The following table will show the strength of such a seam composed of four rivets, and two plates $10\frac{1}{2}$ in. wide,* with drilled holes:

Plates through rivet holes..................	(tearing)	118,125 lbs.
Rivets..	(shearing)	120,260 "
Plates in front of rivets	(crushing)	118 125 "
Solid plates....................................	(tearing)	196,875 "

From this it is seen that the strength of the seam with drilled plates is 60 per cent. of that of the solid plates, or it is about $18\frac{1}{2}$ per cent. stronger than that made with plates having punched holes and the rivets nearer together. It should be noted that a great part of the superiority of the seams made with drilled holes is due to the superior accuracy of the work done in that way, which makes it possible to use larger rivets spaced further apart. It is probable that with the use of some recently designed machines, intended to produce greater accuracy in punching rivet holes, part of the above advantage may be realized with that kind of work. The greatest distance that rivets may be spaced apart without incurring danger of leakage between the plates must, however, be determined more by practical than theoretical considerations. It is certain, however, that rivets may be spaced much further apart than they are in ordinary practice, and the seams still be kept tight, if the work is done with sufficient accuracy and care.

(TO BE CONTINUED.)

Manufactures.

The Proposed Hudson River Bridge.

THE plan for a bridge over the Hudson River, advocated by Mr. Gustav Lindenthal before the American Society of Civil Engineers, is described by Mr. Lindenthal himself as follows:

"The proposed North River Bridge is for six railroad tracks on a floor platform 86 ft. wide (same as East River Bridge); clear height at middle of river, 145 ft. above high tide at 50°

* Wilson's Treatise on Steam Boilers.

* It has been necessary to take for an illustration plates of a different width from the preceding example, in order to get an even number of spaces between the rivets in each case.

Fah. temperature (the floor would sink 4 ft. in summer and rise about the same in winter). Length of middle span, 2,850 ft., to centers of towers, each pier within the legal pier-line of each shore. The end spans are about 1,500 ft. long each, and the total length between anchorages is 6,500 ft., including anchorages. The height of metal towers to lower cable is 400 ft.; to top, 500 ft., which stand on masonry piers 340×180 ft. respectively and are nearly 75 and 180 ft. deep.

"The anchorages are each about 320 ft. long and 180 ft. wide, and are 210 ft. above the pavement. The six railroad tracks pass through a tunnel in each anchorage mass.

"The type of the bridge is that of two suspended huge arch-ribs (or braced arches) supported on steel or wrought towers of great stability, from which they descend back to the large anchorages, which resist the pull from the large arch-cables. The latter are 50 ft. apart, strongly braced together, to resist the deforming effects of passing loads. Each cable has an outside diameter of 4 ft., and will have the smooth cylindrical appearance of a huge bent-metal shaft.

"The cables are inclined toward each other, or 'cradled,' 1 ft. in 10. From them are suspended the platform and the trusses, between which the six tracks are placed. Four wind-cables of 12½ in. diameter are in two horizontal planes, securing the lateral stability of the superstructure.

"The towers are strongly braced inside with heavy members, and on outside with large-sized lattice-filling between the curved columns. On top the arches are held apart by a heavy cross-bracing. The towers are connected solidly at the top and bottom into one coherent structure.

"The architectural features of the bridge were considered of the highest importance and were sought to be obtained in a natural manner without attempts at ornamentation.

"The bridge is to be proportioned for six heavy trains, 1,500 ft. long each, drawn by two of the heaviest known engines. It is not likely that six such trains would meet on the bridge in a lifetime. Ordinarily the loads will only be a small fraction of the assumed maximum.

"The bridge will be proportioned against a wind pressure of 56 lbs. per square foot on all exposed surfaces. The principal provision for it are two wind-trusses (forming the top and bottom of suspended track platform) combined with four wind-cables, each 12½in. diameter and kept under constant tension by a lever arrangement in towers.

"Each cable is surrounded with a steel mantle ⅛ in. thick, leaving an air-space between it and the wire cable inside. All connections with web members will be adjustable during and after erection, so that both cables shall be equally strained from the uniform loads of the superstructure at a middle temperature.

"Cost of bridge alone, about $15,000,000. Time of building, 3½ years.

"A bridge with a middle pier would be more expensive on account of depth of foundation and the impracticability of using wire cables for more than one middle span. The great strength of wire as compared with metal in link-cables makes the longer span bridge cheaper.

"The rigidity of the bridge will be such that all trains will be able to cross it at fast speeds (same as on solid ground) without causing any discernible oscillation."

Marine Engineering.

THE Lockwood Manufacturing Company, East Boston, Mass., is building two large steam dredges to be used on the Cape Cod Canal.

THE activity of shipbuilding on the lakes is shown by the statement that at the Wheeler yard in Bay City, Mich., there are 10 new vessels on the stocks, ranging in size from 700 to 2,000 tons register.

ENGLISH papers report greater activity in shipbuilding and more new orders than for some time past. Recent contracts include two new steamers of 5,000 tons each for the Peninsular & Oriental Company and several other steamers of large size.

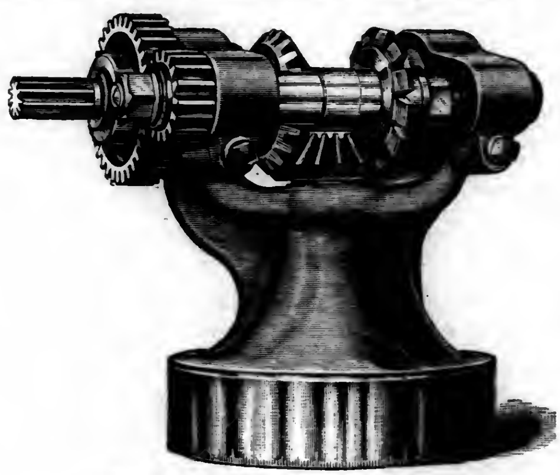
THE Pusey & Jones Company in Wilmington, Del., recently completed a revenue cutter for the Republic of Colombia, South America. The *Marine Journal* describes the vessel as follows: "*La Popa* is an iron vessel, and is the third of her exact class built by the said company within the past few years. She is 120 ft. long on the 8-ft. water line; 20 ft. beam, moulded; 10 ft. 4 in. deep, from top of cross-floors to top of deck-beams amidships, and is sheathed to 9-ft. water line with yellow pine 2⅝ in. thick, secured through plating by ½-in. bolts, and covered with copper sheathing metal. Rigged as a fore-and-aft schooner, and provided with a six-pounder Hotchkiss rapid-firing gun of the most improved type. Vessel driven by a vertical direct-acting, surface-condensing engine, 24 in. diameter, 36-in. stroke; boiler of the Scotch type, 9 ft. 10 in. diameter, 12 ft. long, constructed for a working pressure of 60 lbs. per square inch."

Special Machine Tools.

AMONG the special appliances recently put on the market are a portable arrangement for heating, setting, and removing locomotive tires without taking off the wheels. This consists of a furnace in which gas is generated from oil. The gas is conveyed under pressure from an air-pump to a ring or circular tube pierced with numerous holes, and the tire is heated by the jets of gas from this ring which is placed around it.

Messrs. Pedrick & Ayer, of Philadelphia, have also recently completed a universal milling machine of large size, which is adapted to a very great range of work. This machine was specially designed for locomotive shops, but is adapted for general use. It weighs 6,000 lbs., and much work can be done on it with greater precision and to better advantage than on a planer.

For use with this large milling machine an attachment has been devised which is shown in the accompanying cut. This



MILLING MACHINE ATTACHMENT.

attachment is cast hollow, and is secured to the head of the milling machine by four bolts. The base has an annular T-slot and a hole to insert the bolts.

It is driven by a socket fixed in the spindle of the milling machine, which is key-seated to fit the keyed stud in the attachment. Through the medium of a pair of miter wheels, this stud drives a spindle at right angles to the vertical attachment. This spindle is geared with a shaft in line with it, which is utilized as a cutter or saw arbor for cutting racks, sawing up stock, etc. This shaft runs in Atlas bronze bearings, and can be removed from the attachment by means of the two clamp screws in the clamp bearings.

This attachment can be used either vertically, horizontally, or at any angle around the center, the base being graduated to register its position. Cutter arbors or boring bars can be used in either end of the main spindle. For rack cutting there is no limit as to length, while for boring or milling castings of irregular shape or troublesome to hold in other tools, it will be found very useful. In cutting large gears the cutter spindle is placed vertically and the index head at right angles to the platen. The gear blank is then fed in line with the main spindle of the milling machine. By setting the platen at an angle, bevel gears may be cut. Spur gears up to 6 ft. in diameter can be cut with this attachment in connection with the heavy milling machine referred to above.

Electric Street Railroad Service in Boston.

THE New England Weston Electric Light Company, of Boston, has fitted up an ordinary street railroad car, No. 54 on the Cambridge Division of the West End Street Railroad, of Boston. In doing this it has used a motor built by the United States Electric Lighting Company, of New York, and employs 120 cells of the Julien storage battery. The method of connecting the battery to the motor and the axle is the invention of Mr. William L. Stevens, the electrician of the Weston Company.

The motor is specially wound to adapt it to the service of street traffic. The same batteries run also seven 16-candle power incandescent lamps and two electric bells, the bells being to serve as signals between the conductor and driver, and conductor, passen-

gers, and driver. These lights and bells are all run from the same batteries. The manipulation of the car is made by means of a vertical standard and hand-wheel on the forward platform, leaving the rear platform clear for passengers.

This hand-wheel and standard are readily transferred from end to end of the car, as may be desired.

The reversing gear is operated from either platform, and the car can be run backward in case a switch is missed or for any other cause. This can be done also without removing the hand-wheel.

The speed of the car is controlled *entirely* by this single hand-wheel—stopped, started, or slowed. The ordinary hand-brake is used only to hold the car while standing on an incline.

One of the practical difficulties with former experiments upon the use of storage batteries for street-car propulsion has been that the batteries could not endure the strain and deliver the amount of current necessary to do the work on the car used in Boston. The efficiency of the motor used, however, appears to have reduced the amount of current required to the practicable capacity of storage batteries now in the market.

Various grades up to and including 8 per cent. have been surmounted by this car without reaching 30 Ampères. The best results heretofore obtained, doing this same work, on even lighter grades, have required, it is stated, much greater current strength—in fact, more than the batteries can provide.

These experiments were commenced in March, 1887, taking one of the existing cars on the road and altering its framing to receive the motor battery and other apparatus.

The motor first used was a 5 H.P. shunt-wound machine of the ordinary type, manufactured by the United States Electric Lighting Company. At that time they were unable to ascertain the amount of power required to perform street-car service, and this size of motor was adopted with which to make the first experiments. There were 96 cells of battery connected to the motor and 8 cells to the lamps and bells, making a total of 104 cells.

These experiments were so far completed by the middle of June that the car ran, at irregular times, frequently through the summer, part of the time in regular service, carrying passengers; notwithstanding the fact that the motor was worked up to 8 H.P. frequently, it never failed to perform its service; carried its passengers, made the schedule time easily, and climbed the hills under such conditions of weather and track as would ordinarily occur in summer time.

These trials continued until the latter part of September, 1887, at which time a larger motor of 10 H.P., with enough additional cells to make a total of 120, was put into the car and all the appliances made in a more permanent manner than during the earlier experiments. One series of these experiments was to determine whether it were best that the motor should be connected to one or both axles, the final determination being to connect both axles, thus getting the traction of four wheels instead of two. Notwithstanding the fact that under various conditions of track from mud, ice, snow, and dirt, the car has been able easily to do its work.

The car is now supplied with Tripp anti-friction bearings, manufactured by the Hancock Inspirator Company, Boston.

Experiments have been made to ascertain what maximum speed is necessary for making the average schedule time, and the conclusion has been arrived at that a maximum speed of 10 miles an hour is sufficient and as high as it is safe to run in cities, though this car has been run at 12 miles an hour.

If in places a higher speed would be required or safe, there is a considerable reserve that could be easily applied.

It requires a personal observation of the performance of the car in crowded streets to appreciate the ready control which the driver possesses over the movement of the car around curves, switches, grades, up-hill and down, to improve the opportunities to pass between teams without danger of collision. This car may be stopped on curves or up grades, and started with facility.

The motor used on this car can be also employed where the power is taken from overhead or conduit conductors, as well as from storage batteries.

The Meneely Rolling Bearings for Cars.

THE Meneely Bearing Company, of West Troy, N. Y., has had for some time a new roller bearing in use on one of the trains running on the Albany & Troy belt line trains of the Delaware & Hudson Canal Company. A comparative test was made on November 24, 25, 26, 28, 29, and 30 last of two trains running on this line. Each train consisted of one combination (smoking and baggage) and two eight-wheel passenger cars, but one train throughout was on the Meneely steel rolling bearings (Gibbons' patent), and the other on ordinary bronze bearings. To secure a uniform test, the same engine was used on both trains. The results are reported as follows:

	1. Meneely Bearings.	2. Ordinary Bearings.
Weight of train	159,850 lbs.	154,100 lbs.
Motive power required to start (dynamometer test).	563 lbs.	2,433 lbs.
Distance run (24 round trips)	360 miles.	360 miles.
Coal consumed (anthracite)	15,600 lbs.	18,800 lbs.
Water evaporated	12,081 gals.	14,130 gals.
Engine under working pressure (120 lbs)	20 hours 2 min.	19 hours 40 min.

The saving of coal by the use of the Meneely bearings was thus 17 per cent., or 18 per cent. if the greater weight of train be allowed for. The saving of water was 15 per cent. Of the coal used in running train No. 1 about 94 per cent., it is claimed, was used in running the engine alone; on train No. 2 only 78 per cent. was thus used.

The peculiarity of the Meneely bearing is that the separation of the rollers is effected by means of freely revolving balls. These balls perform no other function and sustain no weight. It is claimed that the independent action of these parts and the avoidance of rigid spacing frames and similar devices constitute the superiority of this over roller bearings previously tried, as they permit flexibility of movement as well as solidity of construction.

Proceedings of Societies.

American Society of Civil Engineers.

A REGULAR meeting was held at the Society's House in New York, December 21. It was announced that the annual business meeting would be held January 18. An invitation to hold the annual convention (in July next) in Milwaukee was presented.

On January 19 various points of interest about the city would be visited, and among them the new bridge crossing the Harlem River, to which the Society was invited by the engineers in charge.

A paper on the Venturi Water Meter, by Clemens Herschel, was then read. This meter is an instrument making use of a new method of gauging water, applicable to the cases of very large tubes, and of a small value only of the liquid to be gauged.

An interesting discussion followed, which was participated in by Messrs. Flagg, Church, Emery, Streidinger, Cross, Brinckerhoff, North, and Brush, the general opinion being that the new device promised to be of great value.

A REGULAR meeting was held at the Society's house in New York, January 4. Mr. Gustav Lindenthal, of Pittsburgh, read a paper on the Hudson River Bridge Problem, with a discussion on Long Span Bridges. The paper described a plan for building a suspension bridge across the Hudson River, for the purpose of bringing the railroad lines terminating on the New Jersey shore into New York City. The site proposed for the bridge was near 14th Street, and the writer's plan provided for a suspension bridge with two steel towers, one on each shore, about 500 ft. high. The bridge would be in three spans, the central span being 2,850 ft. from center to center of the towers, and the shore spans about 1,500 ft. each. After describing the details of the plan, the writer treated briefly of the different elements of construction, and closed by a short discussion on the arch and cantilever types of bridges.

THE ANNUAL MEETING.

THE annual meeting was held at the Society's House in New York, January 18. In the morning the reports of the officers were read. The proposed amendments to the constitution (which we have already referred to) were discussed. They will be submitted to letter-ballot.

In the evening Lieutenant Charles C. Rogers, U. S. N., read a long and interesting paper on the Panama Canal in 1887.

January 19 the members made a visit to the new bridge under construction over the Harlem River, going to the spot in a steamboat. In the evening the usual reception was held at the Society's House.

The officers elected for the ensuing year are: President, Thomas C. Keefer, Montreal; Vice-Presidents, J. James R. Croes, New York, and Robert Moore, St. Louis; Secretary and Librarian, John Bogart, New York; Treasurer, George S. Greene, Jr., New York; Directors, Mendes Cohen, Baltimore;

Joseph M. Wilson, Philadelphia; Charles B. Brush, Hoboken, N. J.; Stevenson Towle, Alphonse Fteley, New York.

Master Car-Builders' Association.

List of subjects, with the committees appointed to report thereon, at the Annual Convention of the Master Car-Builders' Association, to be held at Alexandria Bay, N. Y., June 12, 1888:

1. *Standards and Appliances for the Safety of Trainmen* (this Committee was instructed to report some definite recommendations next year).—H. Hegewisch, U. S. Rolling Stock Co., 35 Wall St., N. Y.; John Kirby, Lake Shore & Michigan Southern, Cleveland, O.; M. N. Forney, 45 Broadway, New York.

2. *Automatic Freight-Car Brakes.*—Godfrey W. Rhodes, Chicago, Burlington & Quincy, Aurora, Ill.; George Hackney, Atchison, Topeka & Santa Fé, Topeka, Kan.; B. Welch, Central Pacific, Sacramento, Cal.; John S. Lentz, Pennsylvania & New York, Packerton, Pa.; W. T. Hildrup, Harrisburg Car Co., Harrisburg, Pa.

3. *The Best Form and Construction of Car Roofs.*—J. D. McIlwain, Grand Trunk (G. W. Div.), London, Ont.; Samuel Irvin, Missouri Pacific, St. Louis, Mo.; L. Packard, New York Central & Hudson River, West Albany, N. Y.; William Forsyth, Chicago, Burlington & Quincy, Aurora, Ill.

4. *Car Heating.*—Frank L. Sheppard, Pennsylvania, Altoona, Pa.; R. D. Wade, Richmond & Danville, Washington, D. C.; Robert Miller, Michigan Central, Detroit, Mich.

5. *Wheels* (this Committee was appointed to confer with a Committee appointed by wheel manufacturers).—J. N. Barr, Chicago, Milwaukee & St. Paul, Milwaukee, Wis.; John Kirby, Lake Shore & Michigan Southern, Cleveland, O.; George F. Wilson, Minneapolis & St. Louis, Minneapolis, Minn.

6. *Journal Lubrication, and the Best Practice for Economizing Oil.*—J. W. Cloud, New York, Lake Erie & Western, Buffalo, N. Y.; H. Roberts, Chicago & Grand Trunk, Detroit, Mich.; J. N. Lauder, Old Colony, Boston, Mass.

7. *The Best Form of Door Hangings, including Grain Doors.*—E. W. Grieves, Baltimore & Ohio, Baltimore, Md.; John P. Levan, Pennsylvania, Altoona, Pa.; John Voorhees, Indianapolis Car Manufacturing Co., Indianapolis, Ind.

8. *How Can Uniformity in the Interchangeable Parts of Cars be Obtained.*—Samuel Irvin, Missouri Pacific, St Louis, Mo.; James McGregor, Michigan Car Co., Detroit, Mich.; John Hodge, Chicago, Santa Fé & California, Streator, Ill.

9. *Committee of Arbitration in Disputed Cases under the Rules of Interchange.*—William Buchanan, New York Central & Hudson River, Grand Central Depot, New York; Robert C. Blackall, Delaware & Hudson Canal Co., Albany, N. Y.; G. W. Cushing, Philadelphia & Reading, Reading, Pa.

10. ***Subjects to be Reported at the next Annual Convention for Investigation and Discussion at the Succeeding Convention.***—Joseph Wood, Pennsylvania Co., Pittsburgh, Pa.; William McWood, Grand Trunk, Montreal, Canada; E. B. Wall, Pittsburgh, Cincinnati & St. Louis, Columbus, O.

11. *Committee of Arrangements for the Next Annual Convention.*—R. C. Blackall, Delaware & Hudson Canal Co., Albany, N. Y.

CIRCULAR FROM SPECIAL COMMITTEE OF THE EXECUTIVE COMMITTEE ON AUTOMATIC FREIGHT CAR COUPLERS.

The Special Committee of the Executive Committee, appointed to consider in detail the matter of Automatic Freight Car Couplers in accordance with the type adopted by the Association, desires to have the opinion of the members of the Association upon the following matters:

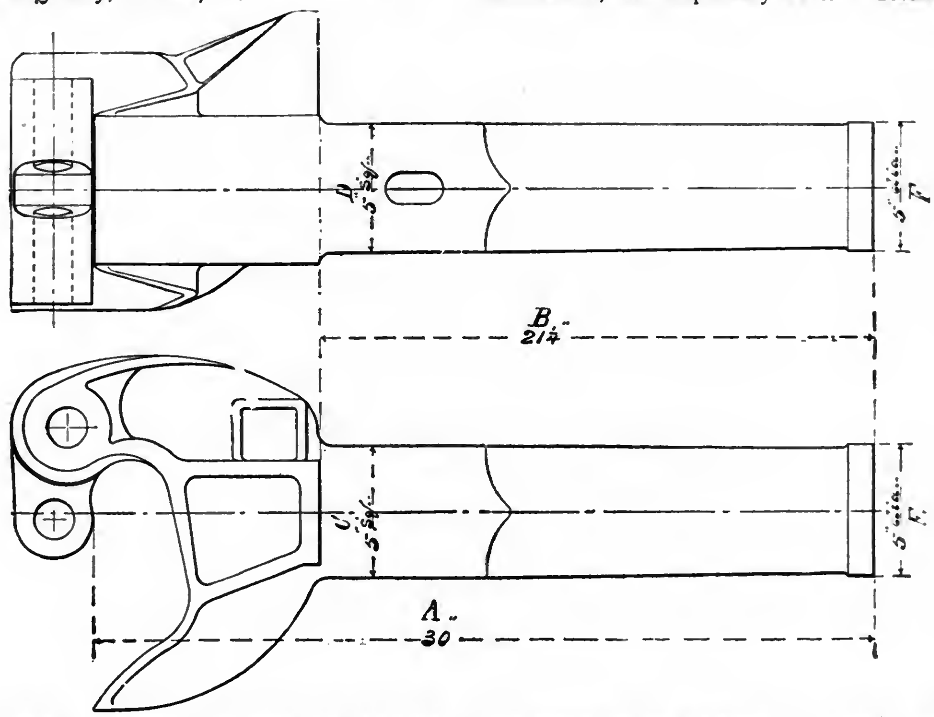
1. The length of the drawhead from the end which bears against the follower-plate to the inside face of hook when closed; marked *A* in the engraving.

2. The length of drawhead from the end which bears against the follower-plate to the face of the horn for striking against end sill; marked *B* in the engraving.

3. The dimensions of drawhead in cross section at the stirrup which carries it; marked *C* and *D* in the engraving.

4. The dimensions in cross section at the end which bears against the follower-plate; marked *E* and *F* in the engraving.

The cuts hereon show the dimensions indicated on the latest Janney freight car coupler, and inasmuch as other freight car couplers have been made with but slight variations on these dimensions, and especially as it is desirable to have a pretty



long shank for the drawhead, in order to balance the weight at the outer end, it is the opinion of the Committee that the dimensions as shown on this cut are desirable dimensions to establish as a standard.

Enclosed are two circulars and an envelope addressed to the Secretary. You are requested to alter the figures in one of the circulars to such as you would recommend, if other figures seem preferable; otherwise, to signify that the figures are satisfactory, sign it and mail as promptly as convenient to the Secretary, so as not to delay the decision of this important matter.

The Committee takes this opportunity to call your attention to a further recommendation, not with a view to secure immediate action, but to enable the members of the Association to be prepared to discuss and vote upon it at the next convention. They consider that dead-blocks should be used with the Master Car-Builders' Standard Coupler. If the dimensions shown on the card are adopted, the dead-blocks should be 9 in. long, measuring lengthwise of the car, and the draft-springs have 2-in. action.

The dead-blocks can be placed 22 in. between centers, as provided by the standard of the Association, provided that the lower face is not less than 38 in. from top of rail when car is empty. As the standard for this height is given at 36 in. by the Association, your Committee recommend that this figure be increased to 38 in., to allow proper clearance for the new form of coupler.

EDWARD B. WALL.
JOHN W. CLOUD.
M. N. FORNEY, *Secretary.*

New England Railroad Club.

The regular meeting of this Club was held in Boston, January 11, President Lauder in the chair. The subject for discussion was "Frogs and Safety Switches."

Mr. Richards opened the discussion with a historical sketch, speaking of the earliest forms of frogs used and of the original forms of switches. He spoke also at considerable length of the various safety switches introduced in latter years, of their merits and faults. He said that the frogs and switches on American roads have much greater service than abroad, owing to the greater weight of our cars.

The discussion was continued by Messrs. Patch, Clark, Lane, Ellis, Coleman, Davidson, and Lauder. Mr. Lane advocated the use of spring frogs. Mr. Ellis said that steel-rail frogs should alone be used where safety is required, and also mentioned the defects of a number of the so-called safety switches. Mr. Lauder spoke of the increased wheel-base of engines and trucks. Incidentally a good deal was said about the great increase of weight in locomotives in recent years, and the consequent increased wear of track.

The subject for the next meeting is Axles, Wheels, and their Relation to the Track.

Western Railway Club.

The regular monthly meeting was held December 21 in Chicago, President Rhodes in the chair.

Mr. Lauder, President of the New England Railroad Club, was present, and was introduced by the President. The Committee on Standard Couplings for Steam Heating presented its report, giving an account of the meeting of the joint committee held in Buffalo. The report was accepted and the Committee was continued, with instructions to attend the general meeting on this subject, to be held in New York.

Mr. Willard A. Smith then read a long and interesting paper reviewing the different systems so far brought forward for heating cars by means of steam from the locomotive; this paper was illustrated by drawings of a number of couplings used. It was discussed by a number of the members present. Mr. Lauder gave an account of experiences of steam heating in Massachusetts.

Mr. J. N. Barr, of the Chicago, Milwaukee & St. Paul Railroad, then read a paper on Specifications for Cast-iron Car Wheels; this was briefly discussed.

The following subjects were selected for discussion at the next meeting: 1. Axles and Journals. 2. The effect of magnetism on watches. 3. Water for locomotive use, and practice in washing out boilers.

A regular meeting was held in Chicago, January 18, with a very large attendance. The first subject—Axles for 60,000-lbs. Cars—was laid over after a short discussion, Mr. Barr promising to prepare a paper for the next meeting.

Mr. George A. Gibbs, Mechanical Engineer of the Chicago, Milwaukee & St. Paul, then read a long and interesting paper on Water for Locomotive Boilers, giving the result of some investigations carried on under his charge for two years past. He also described the practice of his road in washing out boilers.

This paper was briefly discussed by Messrs. Rhodes, Sinclair, F. C. Smith, Brown, Hickey, and Forsyth.

Mr. Herr's paper on Magnetism in Watches was postponed to the February meeting.

OBITUARY.

John F. Anderson, who died January 1 in Portland, Me., was for many years one of the leading engineers of his native State. He made the surveys for nearly all the older lines in Maine, and had charge of the building of several, the latest being the Portland & Ogdensburg. For several years past he had been a member of the Railroad Commission.

General Isaac R. Trimble, who died in Baltimore, January 2, was one of the oldest living graduates of West Point. General Trimble was born in Virginia, and became second lieutenant, First Artillery, July, 1822; he resigned in 1832 to become Chief Engineer of the Baltimore & Susquehanna Railroad, now the Northern Central, and finished the road to York, Pa., in 1837. He entered the Confederate army in May, 1861, in which he performed distinguished service. Since the war he has lived in retirement.

James Walsh Otley, who died in Des Moines, Ia., January 2, aged 68 years, was born in England and educated as a civil engineer by his father, who was Chief Engineer of the Stockton & Darlington Railroad. When 28 years old he came to this country, and eight years later settled in Keokuk, Ia. He made the surveys for the old Des Moines Valley Railroad and took charge of the construction of a large part of the road. After its completion he was Chief Engineer for several years. About 10 years ago he retired from active work. Mr. Otley was one of the pioneer engineers of Iowa, and was much esteemed throughout the State.

Frederick Mercur, who died of typhoid fever at Wilkesbarre, Pa., January 11, aged 51 years, was for many years connected with the Lehigh Valley Railroad. He was, from an early age, employed as a surveyor and civil engineer in Eastern Pennsylvania. His first connection with the Lehigh Valley was as Assistant Engineer; afterward as Chief Engineer he built the extension from Penn Haven to Wilkesbarre. In 1867 he was placed in charge of the Lehigh Valley Coal Company's property as General Superintendent, and held that position till his death. He was considered high authority on all questions connected with mine engineering and coal mining.

Dr. Ferdinand Vanderveer Hayden died in Philadelphia, December 22, aged 58 years. He was born in Westfield, Mass., but went to Ohio when a boy, graduated from Oberlin College in 1850, and afterward studied medicine in Albany, N. Y. In 1853 he became interested in the study of geology and began the series of explorations in the West which continued at intervals for many years, and by which he is chiefly known. In 1861 he entered the army as a surgeon and served through the War. In 1865 he was appointed Professor of Mineralogy and Geology in the University of Pennsylvania, but in 1867 left that position to take charge of the United States Geological Survey of the Territories. He retained this position until his death, doing much valuable work. His chief published works were "The Great West" and "North America." He was a member of many scientific societies.

Charles H. Fisher, formerly Chief Engineer of the New York Central & Hudson River Railroad, died in New York, January 18. He was born in Lansingburg, N. Y., in 1835. He developed at an early age a strong taste for the profession of civil engineering, and at the age of seventeen commenced work on the Racine & Janesville Road in Wisconsin. He was afterward employed for some years on the repairs of the Erie Canal, and in 1860 became a member of the engineering staff of the Central. He remained with the road until the spring of 1868, rising through various grades to the position of First Assistant, which he resigned to take the position of Chief Engineer of the then projected Lake Ontario Shore Road. He made the surveys of that road, and laid out the line on which it was subsequently built. In 1869 he was appointed Chief Engineer of the Central, which position he held until failing health compelled his retirement a little more than two years ago. He built the two additional tracks of the road, the stations at Albany, Syracuse, and Buffalo, and a number of bridges. His last work was the elevation of the tracks and the new station in Rochester. Mr. Fisher was a conscientious and hard-working engineer, always giving the closest attention to his work. The sickness which compelled his retirement and finally caused his death was probably the result of overwork and anxiety.

Professor Balfour Stewart, who died at Balrath, Ireland, December 19, aged 59 years, was a distinguished English authority on physical science. He was born in Scotland and educated at the Scotch universities of St. Andrews and Edinburgh. In 1859 he was appointed to the directorship of the Kew Observatory, and in 1867 to the secretaryship of the Meteorological Committee, which last appointment he resigned on his promotion to the Professor's chair of Natural Philosophy in Owens College, Manchester, in the year 1870, a post which he held until his death. Two years before this distinction was conferred upon him he had been awarded the Rumford medal by the Royal Society for his discovery of the law of equality between the absorptive and radiative powers of bodies. Together with Messrs. De la Rue and Loewy he wrote "Researches on Solar Physics," and he and Professor Tait published their researches on "Heating produced by Rotation in Vacuo." Besides these he wrote a number of treatises, especially on the subjects of meteorology and magnetism. The article in the *Encyclopædia Britannica* on "Terrestrial Magnetism" is from Professor Balfour Stewart's pen. Among the many works of which he was sole or joint author may be men-

tioned the "Elementary Treatise on Heat," "Lessons in Elementary Physics" (1871), "Physics" (1872), "The Conservation of Energy" (1874), and "Practical Physics" (1885). Most of these are text-books on the subjects of which they treat. He and Professor Tait also produced the "Unseen Universe," a work of which 12 editions have been published. At the time of his death he was President of the Physical Society of London, and was a member of the committee appointed to advise the Government on solar physics.

PERSONALS.

W. E. CHAMBERLAIN resigned his position as General Superintendent of the South Atlantic & Ohio Railroad on January 1 last.

D. H. BARRETT has been appointed Chief Chemist in charge of the Baltimore & Ohio Railroad laboratory at the Mount Clare shops, Baltimore.

GENERAL A. ANDERSON, formerly Chief Engineer of the Northern Pacific Railroad, is now Vice-President of the Buffalo, Rochester & Pittsburgh Railroad Company.

Mr. R. MONTFORT, heretofore Resident Engineer, has been appointed Chief Engineer of the Louisville & Nashville Railroad.

G. B. HAZLEHURST has been appointed Engineer of Bridges and Tests of the Baltimore & Ohio Railroad, with office in Baltimore.

LIEUTENANT EDMUND L. ZALINSKI, the well-known inventor of the pneumatic dynamite gun, has been promoted to be Captain in the United States Artillery.

Mr. J. R. GROVES has been appointed Superintendent of Rolling Stock of the St. Louis & San Francisco Railroad, with office in Springfield, Mo.

R. E. BRIGGS has been appointed Chief Engineer of the Denver & Rio Grande Railroad, with office in Denver, Col.

JAMES C. CLARKE, formerly of the Illinois Central, has accepted the position of Vice-President and General Manager of the Mobile & Ohio Railroad.

R. E. RICKER has resigned his position as General Superintendent and Chief Engineer of the Denver & Rio Grande Railroad.

G. H. WORCESTER, late on the Lake Shore & Michigan Southern, has been appointed Superintendent of the Harlem Division of the New York Central & Hudson River Railroad.

C. M. BISSELL is now Superintendent of the Mohawk & Hudson Division of the New York Central & Hudson River Railroad, which, as newly arranged, includes the main line from New York to De Witt. He has for a long time been Superintendent of the Harlem Division.

COLONEL T. M. R. TALCOTT has been appointed Commissioner of the Southern Railway & Steamship Association. He was for many years connected with the Richmond & Danville Railroad, but for two years past has been Vice-President and General Manager of the Mobile & Ohio. Few men could be found so well fitted for his new position as Colonel Talcott; he has always been a close student of traffic questions, and no one, probably, is better acquainted with Southern railroad business. Colonel Talcott's reports, when he was in charge of the Richmond & Danville, were models, deserving study by all railroad managers.

NOTES AND NEWS.

The French Navy.—A report of considerable interest has just been prepared by M. Menard Dorian upon the French Navy. According to this report, the French marine comprises 3-6 vessels of all kinds, viz.: 18 first-class ironclads, 19 ironclad cruisers, 9 ironclads used for coast guard purposes, 4 ironclad gun-boats, 1 ironclad floating battery, 9 battery cruisers, 9 first-class cruisers, 11 second-class cruisers, 15 third-class cruisers, 15 first-class dispatch boats, 31 second-class dispatch boats, 16 dispatch boats, also available for transport purposes, 8 dispatch boats, also available as torpedo boats, 16 unarmored gun-boats, 12 chaloupes, each carrying a gun, 11 steam chaloupes, 10 torpedo boats for the open sea, 62 first-class torpedo boats, 41 second-class torpedo boats, 7 vedette torpedo boats, 10 first-class transports, 10 second-class transports, 4 third-class transports, 13 sailing ships, 29 ships used for fishing protection purposes, and 3 training ships.

The French marine has been engaged during 1887 upon the construction of no fewer than 92 vessels, viz.: 8 first-class ironclads, 4 ironclad gun-boats, 1 ironclad cruiser, 2 battery cruisers, 3 first-class cruisers, 2 second-class cruisers, 6 third-class cruisers, 1 torpedo gun-boat, 3 dispatch boats, 2 torpedo dispatch boats, 54 other torpedo boats, 3 dispatch boats, also available as transports, 1 transport, properly so called, and 2 sailing frigates. In the course of 1888, further new vessels will be undertaken to an estimated cost of $9,200,000.

Casting a Large Steel Gun.—An experimental gun of steel was cast January 11 at the works of the Pittsburgh Steel Casting Company in Pittsburgh. Several months have been passed in making tests and experiments and in preparing the mould. The cast was made in the presence of the Government steel inspectors now on duty in Pittsburgh. The gun is of Bessemer steel, and the mould was made on the Rodman plan. The charge of iron in the converter was 16,500 lbs., and the time occupied in making the blow was about 30 minutes. Only two minutes were required to pour the metal into the mould. The whole operation of making the gun was in charge of Mr. Hainsworth, Superintendent of the works.

The company is also to bore out the gun, and has had special machinery put in for that purpose. When finished it will be of 6-in. bore, will be 16 ft. 1½ in. long, and will weigh about 5½ tons.

Should the gun meet successfully the Government tests, an important advantage will be secured, as a cast gun is necessarily much less costly than a built-up gun of the same size.

Blast Furnaces of the United States.—The condition of the blast furnaces on January 1, with their weekly capacity, is reported by the *American Manufacturer* as below:

Fuel.	In blast.		Out of blast.	
	Number.	Capacity.	Number.	Capacity.
Charcoal	73	13,237	100	11,692
Anthracite	117	35,259	83	19,984
Bituminous and coke	151	92,224	63	29,344
Total, Jan. 1, 1888	341	140,720	246	61,020
Total, Jan. 1, 1887	332	127,660	256	60,446

As compared with the previous month (December), the January statement shows little or no change in charcoal and anthracite furnaces, but a reduction of 1,070 tons in the capacity of the bituminous furnaces in blast.

Steel Rail Production.—The American Iron & Steel Association reports the production of steel rails in 1887 and 1886 as follows, in tons of 2,000 lbs.:

	1887.	1886.
First half-year	1,154,193	707,447
Second half-year	1,141,401	1,042,452
Total, year	2,295,594	1,749,899

Of the total production last year, 1,239,115 tons were made in Pennsylvania, 722,651 tons in Illinois, and 333,828 tons in other States.

The Nicaragua Canal.—The steamer *Hondo*, with the engineering party for the Nicaragua Canal survey, arrived at San Juan del Norte (Graytown), Nicaragua, in due season, and work was begun at once. The headquarters of Chief-Engineer Peary were established on San Francisco Island, at the junction of the San Francisco River with the San Juan, where permanent quarters will be provided. Besides the headquarters party, there are six parties in the field; five of these are assigned to divisions along the San Juan River, and the sixth is the hydrographic party, which is surveying the harbor of Greytown and the proposed entrance to the canal. The surveys are to be very carefully made, and minute records will be kept.

The Stabler Foundry.—The sons of the late Edward Stabler, of Sandy Spring, Md., have presented to Swarthmore College the foundry of their father, with all its appliances and patterns. In this foundry was cast all the metal work of the presses and seals made by him for the various State and city governments, corporations, and courts of law throughout the country; for the several departments of the national Government at Washington, and for its consular agents all over the world. Here, too, were made the steel dies for the gold and silver medals of the Maryland Institute, and many other works of a similar character. This valuable gift will become a part of the foundry of the department of engineering and the mechanic arts at the College, and will add largely to the means of instruction in this direction.

The Barbed Wire Fence Patent.—The United States Circuit Court for the District of Northern Iowa, in a suit by the Washburn & Moen Company against manufacturers at Cedar Falls, has decided that the Glidden patent, under which

the suit was brought, is not valid. This decision was based upon evidence submitted to the Court to the effect that as early as 1859 one Alvin Morley, of Delaware County, Ia., had mounted a wire fence with a barb formed substantially in the same manner as described in the Glidden letters patent ; that a panel of this fence was exhibited at a county fair held in Delhi, Delaware County, in 1859, and that Morley constructed within two or three years afterward several pieces of fence of this description in the neighborhood. It is also claimed that between the years 1860 and 1873 several other fences with barbs of similar construction were put up by others in Delaware County.

The witnesses included several persons who had seen the fence at the time stated and a blacksmith who had made for Morley a rude machine for bending the barbs. A specimen of the barbed wire made in 1859 was also shown. Morley, it appeared from the evidence, was a man of much mechanical ability, but very eccentric, and he finally died in a lunatic asylum.

The courts have heretofore sustained the Glidden patent, this decision being the first one against it. The case will undoubtedly be appealed to the Supreme Court.

The Pennsylvania Railroad Employés' Benefit Fund.—The Pennsylvania Railroad Company has followed the example of the Baltimore & Ohio by adding to its employés benefit fund a savings fund arrangement. Under an order recently issued any employé of the company can make deposits with agents designated by the company ; these agents are well distributed over the company's lines, so as to be accessible to all. On all such deposits interest at the rate of 4 per cent. yearly will be allowed. Depositors can draw their money from any of the agents on giving 10 days' notice. Interest not drawn will be added to the principal yearly.

New Russian Railroad Work.—Notwithstanding Russia's financial difficulties, it is understood that the Minister of Finance will agree to the request of the Minister of Ways and Communication to provide the sum of $3,750,000 toward double-tracking sections of the principal Russian railroads. The sections selected are : On the Petersburg-Warsaw Railroad, from Toroshino to Pskoff : on the Moscow-Brest, from Smolensk to Viazma ; on the Koursk-Azoff, from Slairansk to Lozovoi ; and on the Kozloff-Voronez, from Kozloff to Griazi. On all these railroads traffic is rapidly increasing, and other sections will have a second line laid down as soon as funds will allow of it. The Minister of Ways and Communication has also asked for credit for $1,500,000 for the Transcaucasian Railway, in order to enable it to increase its rolling stock running between the Caspian and Batoum. It is anticipated that the failure of the maize crop in America will cause a very heavy demand for maize in the Caucasus, where vast quantities are grown. Another application has also been made by the Minister for a credit to enable him to start the Murom-Kazan Railroad, which is intended to connect the important Volga town of Kazan with the Russian system. The line will eventually be carried on from Kazan to Perm, and join the railroad running thence from Perm to Ekaterinburg, thereby completing the Northern Siberian line as far as that point. In regard to the Southern Siberian Railroad from Samara to Ufa, the track is announced to have been leveled throughout, and a considerable mileage of rails laid down. A large bridge over the River Bieli will be constructed the first thing in the spring ; the piers are already nearly complete, and it is hoped that by the following winter the line will be open for traffic. Altogether, in spite of the Minister of Finance declaring in his budget at the beginning of the year that the building of railroads would be stopped, there would appear to be more activity than ever.—*Engineering.*

Copper Production of the United States.—The production of copper in the United States in 1887, according to the *Engineering and Mining Journal*, was as follows, in tons of 2,240 lbs.:

	Tons.
Lake Superior Region	33,330
Montana	35,223
Arizona	8,036
Colorado	893
Other States and Territories	1,090
Lead smelters	555
Total from native ores	79,107
From foreign ores	2,366
Total	81,473

The principal feature of this statement is the increase of the Montana production. The output from that Territory last year exceeded that of the Lake Superior Region, formerly the chief copper-producing district in the country. The Arizona output also increased largely last year.

Of the Montana product the Anaconda mines alone turned out 25,446 tons, exceeding by 5,092 tons the output of the Calumet & Hecla Company, once the leading producer.

Electrical Subways in New York.—The Board of Electrical Control, which is charged with the work of putting the electric wires in New York underground, has presented a report for the year 1887, the substance of which is as follows :

The report reviews the work of the old Subway Commission very briefly and explains the relations of the construction company known as the Consolidated Telegraph & Electrical Subway Company to the Board. This company is simply authorized to build the subways designed by the Commission and to rent space in them to the electric companies on fair and impartial terms, to be approved by the Board. The Department of Public Works has full control over all excavations made by the company, and its profits are limited to 10 per cent. on the money actually invested, any excess going to the city, and its books and accounts are subject at all times to inspection by the Comptroller. The Commission considers that every safeguard for the interests of the city has been provided in its contract with the Construction Company.

The work of building subways was resumed as soon as the new Board was organized, in July, 1887, and at the close of the working season 189,918 ft. of trench had been excavated for the laying of subways. Of single ducts for telegraph and telephone service 903,180 ft. had been constructed, besides 4,050 ft. for distributing service and connections to central stations. The average capacity of each duct is estimated at 80 wires, making the total capacity of the subways for telephonic and telegraphic service 72,254,400 ft., or about 13,700 miles of wire. For arc lighting and power service 254,250 ft. of single duct have been laid, capable of accommodating nearly 500 miles of wire, and for incandescent lighting 186,745 ft. of conduit has been built, carrying 560,235 ft. of conductors. It is claimed, on the strength of these figures, that the capacity of conduit already provided in the city by the Board of Electrical Control is considerably greater than is now provided in any other city in the world, so far as the Board is informed.

On all the streets where conduits have been constructed the companies whose wires have been provided for have been notified to remove their poles and wires from the surface within 90 days, and if they do not comply with the order ample provision is made in the law by which the local city authorities may proceed to remove the obstructions. The Western Union Company has already about 500 miles of wire in the conduits, the Metropolitan Telephone & Telegraph Company has about 1,000 miles, and the Edison Company more than 100 miles under ground. These companies, with the Brush and others, are preparing to enter the conduits at many points, and if the local authorities act energetically with the Commission when the 90 days of notice has expired, many of the streets must necessarily be freed soon from the dangerous and unsightly pole systems.

The actual number of poles already removed from the streets as a result of the work of the Board is 217. Many more poles could have been removed had the wires of the Fire and Police Departments been provided for by the city authorities. The Board has no control over these wires, and cannot order down the poles supporting them.

Very little progress has been made by the Board in making and enforcing regulations for the continuance of the wires overhead where this is necessary, either before the subways are completed or in connection with them after they are built. The Board has adopted some rules to minimize the danger from electric light wires, but owing to the lack of inspectors, who cannot be employed until some certain provision for their payment is made, few improvements have been made in the condition of the overhead system, and little attention is paid by the companies to the rules and regulations established by the Board.

The Board has constructed subways in different localities differing greatly in design to accommodate the wants of the companies and the nature of the locality. The Commission holds that liberty of choice under certain restrictions should be liberally accorded to the companies for whose service the subways are intended, and it has acted on this principle. In the matter of additions to the conduits for the purpose of making local connections this same liberality has been shown, the Board allowing the Construction Company to furnish whatever the several companies desire for themselves from the manholes to the points desired to be reached. A system of inspection of the subways and the wires within them and their maintenance free from moisture and gases is being devised ; but in this, as in other matters, the Board is seriously embarrassed by the lack of funds. An appropriation for the pay of inspectors is asked for.

THE RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

PUBLISHED MONTHLY AT No. 45 BROADWAY, NEW YORK.

M. N. FORNEY, ... Editor and Proprietor.
FREDERICK HOBART. . . . . Associate Editor.

Entered at the Post Office at New York City as Second-Class Mail Matter.

SUBSCRIPTION RATES.

Subscription, per annum, Postage prepaid $3 00
Subscription, per annum, Foreign Countries 3 50
Single copies 25

Remittances should be made by Express Money-Order, Draft, P. O. Money-Order or Registered Letter.

MR. J. HOWARD BARNARD, 7 Montgomery Avenue, San Francisco, Cal., is the authorized Western Agent for the JOURNAL.

MR. FREDERIC ALGAR, Nos. 11 and 12 Clements Lane, Lombard Street, London, E. C., England, is the authorized European Agent for the JOURNAL.

NEW YORK, MARCH, 1888.

WE have received two copies of the work on bridge construction which was mentioned in this column last month. Both of them were received too late for use in the present issue, but we hope to reproduce some extracts from the book hereafter.

THE Panama Canal, or rather its management, is very severely criticised in a recent number of *L'Economiste Français*, a high authority on economic questions. M. Leroy-Beaulieu, the Editor, considers it impossible for the canal to be completed within five years, even on the new plan with locks, and he is unwilling to accept M. de Lesseps's promises either as to the time or the amount needed to finish the work. He points out also that there is a much larger sum to be provided than the Canal Company is willing to admit, and that it can be raised only with great difficulty.

The canal seems to be faring badly on all hands just now, and the collapse of the present company seems to be only a question of time. It is to be regretted that so great a project had not fallen into more capable hands.

THE question of heating cars is briefly discussed by the New York Railroad Commissioners, in their report for 1887. After referring to the act passed by the last Legislature of the State, which requires the adoption of some method of heating by steam from the locomotive, the Board say that it will require some time and more practical experience to determine which of the systems already proposed is the best. They refer to the efforts made by some of the leading railroad companies to secure a uniform coupling for steam pipes, and recommend the adoption of such a coupling.

The Board, apparently, is not altogether of the opinion that steam heating will prove the best, and refers to several systems of heating by stoves with coverings of sufficient strength to resist breakage with provision of extinguishing the flames in case of accident. So long as the present law is in force, however, the discussion of this is hardly necessary.

In this connection the Board very sensibly calls attention to the necessity of proper ventilation of cars in connection with any system of heating, and the report refers with some severity to the difficulty which has been experienced in inducing railroad companies to take any steps in that direction. This question of ventilation the Board considers almost equal in importance to that of safety, in any discussion or settlement of the heating question.

THE great work undertaken by the New York Railroad Commissioners some time ago of procuring strain-sheets of all the railroad bridges in the State is not yet entirely completed. It was expected that the bridge report would be submitted with the annual report for 1887, but its preparation was not completed in time; it will, however, appear shortly as a supplement.

The amount of labor required in the preparation of this report has been enormous, as engineers will readily admit if they consider for a moment the mileage of railroad in the State and the number of bridges.

THE Russian Government has finally granted the concession for the building of a pipe line from the oil fields of Baku, on the Caspian Sea, to the port of Batoum, on the Black Sea, which has been the great shipping point for Russian oil ever since the railroad between the two places has been completed. The concession is made to a company of French and Russian capitalists, who propose to put down a single line of 8-in. pipe between the two points. For about one-half the distance this line will follow the railroad, but its eastern half will be located on a different and more direct line.

The details of the construction of the line and of the pumping stations and machinery required will follow very nearly American practice, the only exception apparently being that some greater precautions than are used here for the protection of the pipe will be required in the wilder and less inhabited parts of the country through which it passes.

The total length of the line will be 497 miles; the highest summit to be overcome is about 1,100 ft., and no serious difficulty is anticipated in the construction or in the operation of the line. Twenty-four pumping stations are provided for by the plans, and such arrangements will be made that the pipe can be duplicated in case of necessity, although it is not expected that a second pipe will be needed for some years to come.

The export of Russian petroleum has been heretofore limited by the fact that the only line by which it can reach European markets has been the railroad line from Baku to Batoum. The capacity of this line is limited by the very high grades which had to be used in carrying it through the Suram Pass, and its charges have been necessarily high. It is anticipated that when the pipe line is in operation the quantity of oil sent can be very largely increased, while at the same time the charges can be considerably reduced. Under these conditions it is thought that Russian oil will become a much more formidable rival to the American product than has been heretofore the case.

It is stated that as soon as the pipe line is open the principal seat of the refining industry will be removed from Baku to the Black Sea end of the line. There are two reasons for this, the first being that the business of refining can be more advantageously conducted there, and the second, that a market can be found for the refuse as fuel for the Russian naval vessels and also for the commercial vessels navigating the Black Sea. This refuse has long been used for fuel on the steamers navigating the Caspian Sea, but their number is comparatively small, and a very large amount of it was practically wasted and thrown away. On the Black Sea, however, the number of steamers is very much greater, and the petroleum refuse can be supplied to them at a price relatively very much lower than coal.

THE question of the organization of a naval reserve is now attracting much attention. It was brought before the United States Naval Institute at a recent meeting in New York, by a long paper by Captain A. P. Cooke, which dealt chiefly with the question of the proper organization of such a reserve, and did not refer to any provision for a reserve of ships. Captain Cooke urged strongly the necessity of organizing and training a naval militia, and sketched a plan for its training. This force would be composed of both officers and men, and would at all times be ready for service in case of an emergency requiring its services.

If the Navy is to be increased, and especially if reserve ships are to be provided, some such organization will be a necessity. Its connection with the active Navy should be as close as possible, as a reserve must depend upon naval officers for its training, and must act with and under their command in time of war. The management of such a force, however, and the proper adjustment of the many questions which must arise in connection with it, will not be an easy matter.

THE dynamite gun, according to the report of the board of naval officers who examined it, has met all the requirements made so far, and has established its claim to a place in warfare. The contract under which this gun was to be furnished to the Navy called for a range of one mile; this was exceeded in the trials made, and it is thought that two miles can be reached. The accuracy of aim is considered remarkable; this is probably due to the fact that the force of compressed air can be regulated and calculated on with much more certainty than that of gunpowder. The naval board consider it a valuable weapon for defence and, in certain cases, for attack. The gun has the further merits that its cost is not great, and that its manufacture is not difficult.

The trials of this gun on the boat which is specially built for this service will be watched with much interest.

SOME remarkable experiments have lately been made with the Graydon projectile, which is a steel shell with a charge of dynamite, and is intended to be fired from an ordinary gun with gunpowder. This shell was tried in 1886 with a 3-in. field-piece and soon after from a 4½-in. siege-gun, near San Francisco. The latest trials, in December, were at Sandy Hook, with a 7-in. gun; the projectile weighed 122 lbs. and carried a charge of 2⅝ lbs. of dynamite.

The destructive effects of the explosion of these projectiles were very great. This was expected, the main purpose of the trials being not to settle this point, but to ascertain the possibility of using shells loaded with high explosives with an ordinary cannon. So far this has been done with the Graydon shell without accidents from premature explosion, but the amount of dynamite is very small in comparison with the weight of the projectile. For heavy charges the pneumatic gun is at present to be the only available weapon. The ordinary gun, however, has the advantage of a greater range, and if it is found to be possible to use a dynamite shell the destructive power of the projectile will be much increased.

THE 111-ton gun just completed for the English Navy, which is illustrated on another page, is probably the most destructive single weapon which has ever been made. Its full capacity will not be known until after the tests, for which preparations are now being made; but there is no doubt that it exceeds in projectile power any gun heretofore manufactured, including the great Armstrong and Krupp guns made for the Italian Government, which have heretofore been the most powerful pieces of artillery in existence.

A question, however, which is still to be tested is whether such a tremendous engine of war will be worth to its owners what it has cost. The difficulties attending the firing of so large a gun are not slight, and even the handling of the projectiles used with it and the arranging for its proper loading require ingenious and complicated machinery, which must be always liable to get out of order at a critical moment. While even on land the difficulties attending proper aiming and firing of such a gun are not inconsiderable, when it is mounted on so unstable a base as even the largest ship must be, they will be greatly increased. Moreover, the expense of firing so large a gun is very great, and when even a single shot is missed in action the loss must be taken into account.

It is, we think, hardly an open question with the best authorities on the subject that the amount of money expended in a gun of this kind could be used to much better advantage in the construction of several smaller and more manageable pieces. The cost of guns, it must be remembered, does not increase in direct ratio to their size, but very much more rapidly, while the difficulty of handling them also increases in almost the same proportion as their cost.

While a gun of this kind must produce great destruction when its projectiles strike where they are intended to, it may almost be regarded rather as a costly toy intended to feed national vanity, than as an actual useful addition to the armory of its owners.

As the penetrating power of a projectile from this gun will probably be greater than that of any yet used, ingenuity will now be applied to the construction of a vessel with armor strong enough to resist its impact.

A TUNNEL under the East River to connect the Long Island system of railroads with the New York Central is proposed. The plan provides for an underground line from Long Island City under the river and under the streets of New York to a point near the Grand Central Station, with an extension running nearly to the Hudson River and thence southward parallel with the river to a

connection with the Hudson River tunnel. For most of the distance across the city the tunnel is to be 50 or 60 ft. below the street level.

The project is not a very promising one as it stands from a financial point of view, although it is probably practicable as an engineering work. The line is too far north to accommodate the great body of the travel between New York and Brooklyn, and it is somewhat doubtful whether it could command business enough to pay interest on the very large amount which the tunnel would cost.

THE Hudson River tunnel continues in a state of suspended animation. No work is in progress at present, and very little was done at the time of the last resumption. Apparently the lack of funds is the only reason for this, as it was stated last year that everything about the work was found in good condition when it was reopened.

MAYOR HEWITT has proposed an addition to the facilities for passenger transportation in New York, to consist of a tunnel or underground line from the Grand Central Station in Forty-second Street to the City Hall. This tunnel, the Mayor suggests, should be built on a line as direct as possible—the one he lays down is partly under the streets and partly under private property—and it should be owned by the city, and leased to a corporation which will operate it under proper restrictions. In connection with the New York Central tracks north of the Grand Central, it will form a new rapid transit line from the Harlem River to the City Hall. As the Central Company already owns a considerable part of this line, and as it is in the best position to utilize the whole of it, the Mayor proposes that that company shall build the new portion and operate the entire line, the city refunding the cost of construction.

Without discussing here the questions of city ownership or of the proposed method of construction, it would seem that the Mayor's plan is defective in several points. The first, and perhaps the least serious, objection to it is that such a trunk line of city travel as he proposes should not end at the City Hall, but should be continued to the Battery. While it is true that an enormous traffic would come to such a line from the Brooklyn Bridge, and that a very large proportion of the passengers do not go south of that point, it is also true that there is a large traffic originating further south, which needs and should have accommodation.

A second objection is, that the existing tracks of the New York Central north of Forty-second Street, while they would serve the purpose for a time, would certainly be overtaxed in a short time if a great volume of city travel were thrown upon them in addition to that which they now carry. In a few years additional tracks would be needed, and it is a question whether it would not be better to build them at once, and on a different line from Fourth Avenue.

The third, and perhaps the most important objection to the plan, is that it does not provide for the West Side, which is the growing section of the city. At present the East Side furnishes the larger volume of traffic, and it would be accommodated by the Mayor's line; but this condition is rapidly changing, and there is no doubt that in a very few years it will be the West Side travel which will preponderate, and must be considered. No plan for new lines can be called complete which does not take this into account.

The Mayor's plan, however, contains some valuable ideas, and is well worth careful consideration. With some expansions, such as have been briefly suggested, it may prove the solution of the problem.

THERE is an opening for railroad contractors in Morocco. The King of Belgium recently sent an Embassy to that country, and chief among the presents sent with it to the Sultan was a locomotive and a passenger car. Now there is not, we believe, in all Morocco a single mile of railroad track of any description, and as the Sultan will undoubtedly want to use his present, the first contractor who gets there will probably have an excellent chance for the job, and will, moreover, not be limited by any inconvenient questions as to prices. The only trouble is that in Morocco the Secretary of the Treasury pays bills when he gets ready—and it generally takes him a very long time to get ready. Moreover, that official is, we believe, clothed with full authority to apply the bastinado and the bowstring to any persistent or troublesome creditor who might presume to disturb his rest with inconvenient or unseasonable demands for payment.

RUSSIAN RAILROADS IN ASIA.

VERY few people appreciate or understand the immense amount of work which the Russians have so far accomplished on their line into Central Asia beyond the Caspian Sea. The telegraph recently informed us that this line had crossed the Amu-Daria River (the ancient Oxus) at Tcharjui, and was pushing rapidly forward toward Samarcand. Now, while most of us have heard of Bokhara and Samarcand, of the Oxus and of other names along the line, they occur to us rather in connection with history and poetry than with actual modern fact and commerce.

To understand the actual railroad progress so far accomplished, we must remember that the Russians now control, in effect, the entire Caspian Sea and the countries which surround it. They have free communication with its waters, both by rail and by the great water highway of the Volga, and their new line starts from its eastern shore at Mikailoffsk. This point is already well advanced to the eastward, being north of and almost on a line with the central portion of Persia.

From Mikailoffsk the road runs east by south, following the foot-hills of the mountain chain which forms the northern boundary of Persia, through Kizil-Arvat to Askabad. Here it makes a long detour to the north to avoid the almost endless swamps in which the Heri-Rud looses itself, and reaches Merv at a distance of about 425 miles from the Caspian. Both strategically and commercially Merv is an important point, and it will be equally important as a railroad town, for there the line will divide into two branches.

The one which is now in progress is completed, as was said above, to Tcharjui, at the crossing of the Oxus, about 170 miles. It is nearly finished to Samarcand, 75 miles still further, and will be pushed on through the 130 miles of very easy work which will carry it to Tashkend. This will be undoubtedly finished before the end of the year, and the terminus will then be 800 miles beyond the Caspian, and within easy reach of the western frontier of the Chinese Empire.

Commercially speaking, this branch of the road will be by far the more important. It follows nearly a very ancient highway of trade, and passes through several towns which have been for ages centers of the commerce carried on by caravan. In a not impossible contingency it may be carried further east and even into China itself—that is, if the mountains of the Central Asiatic plateau do not interpose insurmountable obstacles. It is a little too soon, perhaps, to speculate on such possibilities, but it may be that hereafter this will be a part of the Asiatic transcontinental line which will furnish an outlet to the Chinese system of railroads which will one day exist—though hardly in our generation.

The Russians are not troubling themselves as yet about these future possibilities, and they are most concerned at present about the southern branch of the line. This cannot be built just yet without involving complications which the Government is not ready to assume. It is, however, well understood that all the necessary surveys have been made, and that when the time comes the material will be ready to build the line quickly from Merv due south to Herat, and thence east to Cabul and the frontier of British India. Besides the surveys and the material there is ready a large force of soldiers whose experience has made them trained railroad-builders, and who are well provided with the implements needed for their work.

This line, it must be understood, has been built and is so far operated purely as a military road. Its sole purpose so far has been to consolidate and secure the Russian control in Central Asia, and to prepare the way for further aggression, either in the direction of China or India. In following the military line, however, it has also been necessary to follow the natural line, and there is little doubt that when the present rigorous management is so far relaxed as to permit commerce as well as war to be considered, a traffic of value and importance can be built up. This will take some time, however, and it is not likely that even a beginning will be made until there is a marked change in the policy of the Russian Government. The line is there, however, and some day it will be utilized.

From Merv to Herat and Cabul once built, it would not take long to join the English frontier line. Could the jealousies of the English and Russian governments be settled, a continuous rail overland route to India would be possible within two or three years. Such a thing, however, is not to be hoped for, much less expected.

In addition to this Central Asiatic line, the Russian Government has begun another, which, while less important from a political point of view, has a more directly pacific and commercial purpose. This is the great Siberian line, which is to cross Southern Siberia and find its terminus in the settlements on the Amoor River. While this line, like all undertaken by the Government, is largely controlled by military considerations, it has a definite purpose beyond that, and is meant to develop the resources of Southern Siberia and to aid the commerce now carried on overland with China. There is no doubt that there are considerable possibilities for the line in both directions.

The military necessity for the Siberian line, however, is not considered pressing, and it will advance slowly for some time to come. The purpose is to continue it steadily, however, and it may be only a few years before a continuous line extends from St. Petersburg to the Pacific.

Little Delays.

IT is an undeniable and also an unfortunate fact that very few railroad managers seem to realize the trouble and annoyance caused by small delays to passenger trains. Obstructions that will produce serious delay are generally guarded against with care ; when they do happen there is usually some valid excuse for them, and provision is made for forwarding passengers as quickly as possible ; but even on the best-managed lines the delay of ten or fifteen minutes is generally accepted as inevitable, and no special pains seems to be taken to avoid its recurrence.

Now it is just these ten or fifteen minute stoppages that try the patience of passengers and set them grumbling. The man who goes from Philadelphia to New York, for instance, and finds that the train is ten minutes late in leaving the station and that some other little delay arises on the line, so that he reaches his destination just too late to meet an important appointment or to make a connection with another road, is the man who leaves the cars with a feeling that there is something wrong about the management and a determination to try the other line next time. Where competition is active and business closely divided, as it is now on most important lines, this feeling is sure to tell on the receipts ; and in the end it will be the line on which there are the fewest little delays which will secure the best share of the business. Did space permit, some striking illustrations of this could be given without going many miles from New York.

It would be possible to name more than one road on which this carelessness as to small delays extends so far that it is almost impossible for a traveler to be sure of his time of arrival, even on a journey of moderate length. Something of this is, perhaps, due to the rage for fast trains. To secure an advantage over a rival line the schedule is cut down to the lowest possible point, so that there is no opportunity for an engineer to make up the five minutes lost at an open draw-bridge, or even the two or three minutes' detention by an unusual number of passengers at an intermediate station, or a temporary block in a terminal yard. Fast time is all very well, and most passengers like it ; but it is also true that ninety-nine out of one hundred travelers would prefer a train which took ten minutes more schedule time to one hundred miles, if they could rely upon arriving at the appointed time.

It is an old saying that it is the little worries of life that kill a man, not the great misfortunes. This has its application in railroad management as well as elsewhere, and when superintendents once fully realize how much the little delays hurt the reputation and popularity of a railroad, it is safe to say that nine out of ten of those which now occur will be avoided.

NEW PUBLICATIONS.

THE GRAPHICAL STATICS OF MECHANISM : BY PROFESSOR GUSTAV HERMANN. TRANSLATED AND ANNOTATED BY A. P. SMITH, M.E. New York ; D. Van Nostrand, 1887. Cloth, 12mo, ix + 158 pages, with 8 plates.

The term statics generally means the science of forces in equilibrium, and has for its object the determination from given applied forces of previously unknown forces,

stresses, shears, or bending moments. The graphical application of statics to beams, roof and bridge trusses, shafts, and other structures has been thoroughly developed, and is recognized as of equal importance with analytical investigations on account of its ease of application and the clearness with which it presents to the eye all the elements of the problem. In this work the graphical method is extended so as to take into account friction and the special hurtful resistances to motion. This is effected by the help of the principle that, when one body begins to move upon another, the direction of the resultant pressure makes an angle with the normal to the plane of contact equal to the angle of friction. The coefficients of friction, known from experiment, are the tangents of the angles of friction, which may hence be constructed for special problems, and from which the forces lost in friction are determined for given data. Since in many cases the applied and frictional forces are proportional to the imparted and lost work, a direct determination of the efficiency of simple mechanisms is effected. These principles, in connection with that of the force polygon, open a new field of graphical analysis in which numerous problems involving friction appear in a clear and simple light, while the analytical solution is often of a difficult nature. The book consists of ten sections or chapters, which treat of the equilibrium and efficiency of mechanisms, of sliding, journal, rolling, chain, and tooth friction, of the stiffness of ropes, and of belting. It is designed as a text-book for technical schools, and also as a guide for the use of machinists and engineers. The plates, although much reduced in size from the original, are in general clear and distinct.

In computing results from formulas there is usually the temptation to carry the numerical work to a far greater degree of refinement than the data of the problem warrant. This is not the case in the graphical method, and the following remark of the author on this point is an important one for consideration by those who use formulæ: "A coefficient of friction is never given with certainty beyond two decimal places, as a glance at the tables of these coefficients shows, and it is safe to assume that in the average case there is an uncertainty of several per cent. In the light of these facts, how worthless is the determination of forces carried out to many decimal places, to hundred-thousandths even, as is the case in many analytical deductions!" This book will undoubtedly tend to give clear, rational views of frictional resistances, and of the work thereby lost in mechanisms, to all who read it with care.

THE ELASTICITY AND RESISTANCE OF THE MATERIALS OF ENGINEERING: BY WILLIAM H. BURR, C.E. SECOND EDITION, REVISED AND ENLARGED. New York; John Wiley & Sons, 1888. Cloth, octavo, xvii + 753 pages.

This book is divided into two parts, first the rational or theoretical, and second the technical or experimental discussion of materials. In the technical part, which is the really valuable portion of the work, embracing over 500 pages, are grouped the data of a large number of experiments, classified and reduced to a form in which they may be conveniently used, with discussions of the laws deduced therefrom, and practical rules and formulas. A comparison with the first edition strikingly illustrates the rapid advance made during the past few years in our experimental knowledge of the properties of materials. The principal changes introduced by the revision are the substitution of later and more precise experiments on wrought iron and steel for some of those previously given, a considerable extension of the discussion of experiments upon columns, and new specimens of specifications for bridge work, showing the practice of leading engineers. Some later experiments and methods are also mentioned in the articles on steel and cement under compression, and in the discussion of riveted joints. The fullness of the matter presented, covering as it does our entire range of knowledge of the elasticity and strength of materials, together with the careful and painstaking manner in which it is arranged and discussed, entitle this book to be called one of the most valuable ever published on this subject.

We observe but one error which calls for public notice. In stating the results of the experiments of Wöhler and Spangenberg upon the fatigue of metals, the stresses per square inch given on pages 709–714 are all about 6 per cent. too large. In these experiments the stresses were measured in centners per Rheinisch square inch, and the author, in reducing them to pounds per English square inch, has evidently regarded the two inches as equivalent, thus making the iron and steel of Germany appear of better quality than was actually the case. No general conclusions regarding the fatigue of metal are, however, influenced by this inadvertence.

The theoretical part of the book will be found to be difficult reading except by those well acquainted with mathematics. In the addendum to Article 24 are given the results for the maximum moments and deflections in beams due to various loads, the span to be taken in feet, and the other dimensions in inches. This mixture of different units seems certainly undesirable in rational formulas, although it is often a convenience in making numerical computations.

The art of stereotyping tends to prevents changes in books, so that often the second edition of a work is a mere reprint of the exact matter of the first edition. In this case, however, there have been made numerous alterations and amendments, while the new matter added gives a valuable record of the many experimental investigations of the past four years.

THERMODYNAMICS: BY DE VOLSON WOOD, C.E., M.A., PROFESSOR OF ENGINEERING IN STEVENS INSTITUTE OF TECHNOLOGY. New York; Burr Printing House, 1887.

This is a work in small octavo, embracing 234 pages, which is especially designed for the course of instruction given by the author, who states that no attempt has been made to adapt it to the wants of others. The experience and success of Professor Wood as a teacher, author, and investigator is, however, so well known, that a book from his pen is sure to command the attention and careful examination of those who teach the subject in technical schools, especially since few works treat it in a manner both comprehensive and clear. The book resembles in plan and arrangement the works of the author on mechanics, and contains a large number of practical examples and problems which cannot but be highly advantageous to students. It may, indeed, be asserted that the solution of numerical exercises is an absolute necessity for the correct understanding of thermodynamics.

The first chapter treats of the general principles relating to heat, temperature, and work, explaining Carnot's cycle,

the experimental determinations of the mechanical equivalent of heat, and the thermodynamic laws. The second chapter discusses perfect gases and the work performed by their expansion under different conditions, while the third treats of imperfect gases, of which the most important is steam, in full detail. Chapter fourth gives the thermodynamics of heat engines, where among other problems is presented the interesting one of the determination of the most economical point of cut-off. In an appendix a recent paper by the author on the luminiferous ether is reprinted.

In describing the thermometer it is incidentally stated that it is possible to reduce the temperature of water several degrees below 32° Fahrenheit before freezing, and that "to secure such a result the water must be kept in a condition of as perfect rest as possible." This fact, if such it be, is new to us. The lowering of the freezing point by pressure is well known, but the general opinion is that water under the ordinary atmospheric pressure cannot be reduced in temperature below the freezing point, except when in a condition of constant agitation.

The author defines Thermodynamics to be "the science which treats of the mechanical theory of heat." This book seems better adapted for the use of students of this important science than any other with which we are acquainted.

A Text-book of Inorganic Chemistry: by Professor Victor von Richter, translated by Professor Edgar F. Smith. Philadelphia; P. Blakiston, Son & Co.

The high reputation of Professor Richter, and the success attending his methods of teaching, have given his text-books a large circulation, both in England and in this country. One of the leading features of his method, in which he differs from most of the older text-books, is the care taken to present theories and facts together, and to show their proper relations. Another special feature of the book is the prominence given to thermo-chemical phenomena and to the law of the periodicity of the elements as affirmed by Mendelejeff, and now widely accepted.

The present is the third American, translated from the fifth German edition, which contains several additions, bringing the work up to the point of the latest discoveries and investigations.

BOOKS RECEIVED.

Scribner's Magazine for March will contain a paper on "Electric Motors" by Mr. F. J. Pope, who is a high authority on electrical matters. This magazine, it is announced, has in preparation a series of articles on railroad construction and operation, written by experts in the various departments and fully illustrated. Such a series will doubtless be of much interest to railroad men, and also to the public, in whose daily life and business the railroad plays so important a part.

General Specifications for Highway Bridges of Iron and Steel: by J. A. L. Waddell, Consulting Engineer. Kansas City, Mo.; Macdonald & Spencer.

The National Sin of Literary Piracy: by Henry Van Dyke, D.D. New York; Charles Scribner's Sons. This is a reprint of a sermon by Rev. Dr. Van Dyke, of New York, which is intended to set forth the moral view of the international copyright question, which is just now under active discussion.

Occasional Papers of the Institution of Civil Engineers. London, England; published by the Institution. The present installment of these occasional papers includes Sizing Paper with Rosin, by James William Wyatt; Southampton Sewage Clarification and House Refuse Disposal Works, by William B. G. Bennett; Tachometry; or, Rapid Surveying, by Bennett Hooper Brough; Propelling Machinery of Modern Warships, by Sidney Herbert Wells—a paper of much interest and value; and the usual Abstract of papers in foreign transactions and periodicals.

A People's University: Address before Cornell University on Founder's Day, 1888: by J. G. Schurman, Professor of Philosophy. Ithaca, N. Y.; published by the University.

Schenectady Locomotive Works: Catalogue. The new catalogue of these well-known works contains a brief history of the Works; some notes on recent improvements in locomotive construction; general specifications for locomotives as built at the Works, and a large number of photographs of engines of different classes, with descriptions. Perhaps the most notable feature of this catalogue is the great increase in size and weight of the locomotives illustrated over those to be found in similar catalogues published only a few years ago.

A Warning from the Edison Electric Light Company. New York; issued by the Company. This pamphlet contains a statement of the patent claims held by the Edison Company, and of the infringements which, it charges, other companies have made. It presents, of course, only one side of the controversy.

The Harris-Corliss Engine: Catalogue. Providence, R. I.; issued by the William A. Harris Steam Engine Company.

Contributions.

Lighting Railroad Cars.

To the Editor of the Railroad and Engineering Journal:

Now that coal can no longer be used for heating railroad cars, it is evident that the use of mineral oils for lighting them will not be long permitted, in which case either gas or electricity must be used for that purpose. How far, therefore, each of these agents can be used to advantage becomes a question of grave importance, and especially if experience should prove that gas will give the best results, as most, if not all, the active interest now taken in the subject by our railroad companies is confined to the use of electricity. Why is that? There is no question that gas as now made for all large cities should be cheaper than electricity for lighting railroad cars, and is certainly more convenient. Why, then, is it not preferred to it for that use? There is a reason, of course, as railroad companies never make expensive experiments merely for the advancement of science; but what it is no one of them, so far as we know, has ever publicly stated. We are therefore left to conjecture until they choose to speak.

Meanwhile, to provide for their not choosing to commit themselves in that way, I ask their attention to the following facts, as I think they give the reason I have referred to, and prove that it is simply prejudice.

It is true that when city gas was only made from coal, and its lighting power was not more than 14 to 16 candles,

it could not be practically used for lighting railroad cars, because (1) to store in their tanks enough of so thin a gas to make its use practical would not only require more storage room than could be conveniently given for that purpose, but the compression necessary for the operation would reduce its light at least one-third; (2) because the burners used at that time, when compared with those used now, wasted at least one-third of the light-giving power of the gas passing through them; and (3) because said gas as then furnished by city companies was not only from one-third to one-half poorer than the gas now furnished by them, but its cost per 1,000 ft. was from one-third to one-half more. And therefore it has not been so used, there being no practical evidence that it can be (except in the one case hereinafter referred to), and because of the natural inference from the facts above given that to make gas practical for railroad use it must be made from oil, requiring the erection of special works for making it, and much cost and trouble in their operation, as when that kind of gas is made in quantity too small to warrant costly management, no care can prevent constant clogging of retorts and pipes by carbon deposits; and it is doubtless as much on that account as from the prejudice above described that companies like the Boston & Albany are now testing electricity for lighting their cars at great cost, although they must know all about gas when used for that purpose, as it has been now for a long time by the Erie, the West Shore, and other companies.

And upon the premises above assumed they are right. But if those premises no longer apply to the question in issue—to wit, whether gas, as now made by city gas companies, or electricity can be best used for lighting railroad cars, taking into the account that when gas is used for lighting them it can also be so conveniently used, in combination with steam from the engine, for heating them. What then? Let us inquire, using for the illustration, so far as gas is concerned, the use made of it by the Pennsylvania Railroad Company, and so far as electricity is concerned, the use hitherto made of it by the Boston & Albany Railroad Company, in both cases for lighting their cars.

The Pennsylvania Railroad Company to my personal knowledge now lights its cars with gas supplied by the Hoboken Gas-Light Company, having sufficient lighting power to permit easy reading in any part of them, and yet the gas is used under 200 lbs. pressure (when first stored, of course) and at the following cost per car lighted for 10 hours, average light—to wit:

Amount of gas used 400 ft., viz., 6 argand burners consuming about 6 ft. per hour each, at $1.60 per 1,000 ft. (the retail price at Hoboken)....	64.00 cents.
Interest one day on $200, the estimated cost of the storage tanks, regulator, etc., used for one car	2.75 "
Labor, pumping and repairs of apparatus used on one car per one day, say................	3.00 "
Total cost....	69.75 cents.

That is, as gas is now used by said company; when it is also used by it for heat, there is no reason why it should cost more than $1.25 per 1,000 ft., in which case its cost for light would be only 55.75 cents, and less yet when we take into account the improvements recently made in regenerative burners, as for the same amount of light they require so much less gas than is required for the burners used at the present time.

Now, in contrast with this showing, what has been done in the use of electricity? The Boston & Albany Railroad Company has been for many months and still is engaged in testing it for lighting cars. It is, therefore, fair to assume that the results obtained are the best possible, as no company has a better reputation for a wise and economical management. And what are those results? As we have been reliably informed, they are an addition of 1,800 lbs. to the weight of the car lighted, and an average cost for its light for one night of $2.63. Whether the figures include interest and repairs we have not learned, but assuming they do, is it not money thrown away to experiment with electricity when gas can be used, as there is no reasonable doubt it can be, at not exceeding one-fourth to one-third of its cost?

H. Q. HAWLEY.

The Weight of Rolling Stock and the Wear of Rails.

To the Editor of the Railroad and Engineering Journal:

IN a recent article in the RAILROAD AND ENGINEERING JOURNAL (page 51, February number) upon Locomotives of the Future you refer to the increased weight of locomotives during the last 30 years as being somewhat like an increase from 10,000 lbs. to 17,000 lbs. upon each driver.

Many years ago, before the days of steel rails, it was stated that English locomotives, which up to that time were mostly made with a single pair of drivers, had been made so heavy as to produce a very rapid destruction of the rails, and that when the weight on each wheel reached six gross tons the metal of the rails *flowed* under the weight.

For several years past, in yards where much switching has been done, the flow of the metal of *steel* rails has been very easily seen. At Milwaukee, where a four-wheel switch engine was passing very frequently over a part of a certain track, but rarely going beyond the point where it could reach the end of a long passenger train, it was very evident that the switch engine would have been more properly denominated a rolling mill than a locomotive, as the rails were being *rolled out* rather than *worn out*, while the rails used only by passenger cars underwent normal wear.

The weight of this rail-crusher was said to be 35 tons (=70,000 lbs.), which corresponds nearly to your statement of 17,000 lbs. upon each driver. Similar phenomena can be seen any day in almost any of the large yards in the Northwest.

This indication of excessive weight on drivers has not attracted the attention it deserves. Our enterprising and progressive presidents and managers have gone on ordering heavier and still heavier locomotives and cars, apparently not dreaming that there can be any excess of wheel weight which cannot be met by an increased weight of rail. It is quite certain that they rarely consult an engineer about it, much less ask him to give the subject a special study.

In a few instances I have endeavored to ascertain by observation the real average bearing area of a wheel upon a rail, but as it required one to get in the uncomfortable position of having his head very near the ground, my observations were not very numerous, yet sufficiently so to satisfy me that the area of contact was surprisingly small. The idea suggests itself that some useful information could be obtained by placing a thin sheet of paper upon the rail and observing the width of the track made thereon by a driving-wheel passing over it.

It will probably be found that the area of wheel contact bears little relation to the weight of the rails, that the tires are not uniformly in good form, that *all* rails do not present the same form of surface nor the same rail at different periods.

If a driver 60 in. diameter secures contact 0.84 in. along the rail there must be an elastic yielding of 0.0012 in. at the center of the bearing. Such a contact may be equivalent to $\frac{2}{3} \times 0.84 = 0.56$ in. by a width varying from say $\frac{1}{2}$ in. to $1\frac{1}{2}$ in. Hence the effective area of contact may vary from 0.28 in. to 0.84 in., producing with 17,000 lbs. upon a driver, over 60,000 lbs. maximum pressure per square inch. This being much beyond the elastic limit of ordinary steel, it easily accounts for the lip so often seen on the heads of the rails.

A simple calculation will also show that a 33-in. wheel carrying 9,350 lbs. will produce the same maximum pressure and a like destructive effect as the 60-in. wheel with the larger load above stated. A chilled wheel, being less elastic, would be even more destructive. A car weighing 25,000 lbs. and carrying 50,000 lbs. load has a weight of 9,375 lbs. upon each wheel. This fact may do something toward accounting for the short life of steel rails at the present time. J. T. Dodge.

Duluth, Minn.

THE MEXICAN IRON MOUNTAIN.

To the Editor of the Railroad and Engineering Journal:

While the existence of a large body of iron ore at this place has been known to many, the magnitude of the deposit is only appreciated by those who have seen it, or by a limited number who have read the reports of a few experts who have visited it professionally.

The most complete account of it was made by Mr. John M. Birkinbine, of Philadelphia, who, I think, examined it in the interest of the Mexican Iron Mountain Manufacturing Company, of Des Moines, Ia., its present owners.

The Iron Mountain, or, as it is called in Mexico, the "Cerro-de-Mercado," is situated a trifle under two miles from the city of Durango, the capital of the State of the same name. It rises from a level plain in a series of mostly vertical cliffs of a columnar structure, though somewhat eased off where it joins the plain by the ore that has fallen from above. On the northwest end or side the ore is in small pieces about right to go into a blast furnace; while on the south side much of the fallen ore is of the same size, still the talus contains more large boulders.

The peaks rise several hundred feet above the plain, one being 700 ft., on which some venturesome person has placed a large cross. The table land of this mass of ore is all of 550 ft. high. The body of ore may be taken as one mile long, one-third of a mile wide, and from 400 to 700 ft. high. It appears to be cut by a dyke of lava, or to have a band of that rock capping a narrow belt of the surface, running nearly east and west. All, or nearly all, the country rock of this part of Mexico, and even clear up into New Mexico, is of this same volcanic rock, in color from white to a light red, very soft at first, but hardening quite perceptibly upon exposure. It is much used for window trimmings and arches of the best houses, and also for rough masonry. If it was within reach of large building centers of the United States it would be a very valuable rock.

In relation to the *kind* of ore here, many mistakes have been made, even by Humboldt and others, it being classed by them as magnetic, while it is doubtful if even a single ounce of that variety exists in the whole deposit. They were probably misled by its crystallization, which is in the form often exhibited by magnetite—octahedrous. However, it is not magnetic; it has no influence on the dipping needle; it is not attracted by a magnet, and its streak is red. It is very properly classed as specular by Mr. Birkinbine.

Chemically it shows from 50 to 68 per cent. of iron, mostly above 60 per cent., low in sulphur, and from a *trace* of phosphorus up to $\frac{6}{10}$ of one per cent. (0.6).

The whole mass of the ore bears evidence of having been in a state of fusion, the pieces of ore being often full of cavities, as if a more fusible mineral had been melted out. Again, in some places large boulders of more than a cubic yard in volume have every appearance of being solid lumps of pure ore, but are found to be only blocks of lava with a superficial skin of iron ore, as if they had been *boiled* in melted iron oxide. It is probable that the whole mass was once magnetite, and now changed to hematite by the agency of heat. The surface of the ore is often covered with perfect crystals, which are not detachable from the mass.

The works of the Mexican Iron Mountain Manufacturing Company are located at the western end of the mountain, distant from it 500 to 800 ft., though 68 per cent. ore is shoveled up within 200 ft. of the stack, and from that point to the mountain or bluff of solid ore is a collection of loose pieces of at least 100 ft. in thickness where it joins, taken on a level with the stock-house floor; how much deeper it extends is not known, further than that ore was found at a depth of 60 ft., when digging a well about as far from the mountain as the stack stands.

The plant consists of a charcoal blast furnace 54×10 ft., with a 40-pipe iron hot blast of 2,000 ft. surface, a Weimer blowing engine, tubular boilers, Crane Brothers' hoist, and Knowles's tank and feed pumps.

A rolling-mill is well along, containing a 10-in. merchant train, a 22-in., and another heavy train, four puddling furnaces, one 450 H.P. Porter-Hamilton engine, and 2 Heine boilers. A machine shop, foundry, pattern shop, etc., are now in operation, doing the company's work and such outside business as they can without interference with repairs and construction now going on.

The furnace is now being relined, and will go in blast as soon as finished, say in three months, after which a steel plant will probably be added.

Fuel is found in the cañons and along the base of the foot-hills, as well as on the table lands, in sufficient quantities to be pronounced inexhaustible—oak, pine, huisache, and mezquite—yielding charcoal weighing 25 lbs. per bushel.

Limestone of rather poor quality is found within a mile of the furnace. As the ore is very rich, a poor quality of stone will do fully as well.

Good clay for making fire-bricks is yet to be found; a good sandstone, containing 95 per cent. of silica, is found about $1\frac{1}{2}$ miles from the furnace.

The climate of this part of Mexico is all that could be desired, in winter varying from the freezing point up to 70°, and in summer never going above 86°, the elevation, 6,700 ft., accounting for the trifling variation. Middle-aged people who have always lived in Durango saw snow for the first time this winter. N.

Durango, Mexico.

THE PRINCIPLES OF RAILROAD LOCATION.

By Professor C. D. Jameson.

(*Continued from page* 63.)

CHAPTER XII.

THE LEVEL PARTY.

The Level Party, as has been said, consists of the leveler and his rodman, and the object of their work is to get the actual height of each station above some known plane, in order to plot the profile of the line and to "establish the grade line."

The leveler must proceed with his work a certain distance behind the transit party—never more than one day and not less than half a day.

The first thing to be done by the leveler in starting any new line is to get some point to start from. When the new work connects with some old-established line, then the leveler should start from some point on this old line, the height of which he can obtain. But if there is no permanent point, the height of which is known, then the leveler must establish some point and get its height above the sea-level as exactly as possible with the aneroid barometer; then proceed with his work, using the height thus obtained.

This permanent point is called a Bench Mark, and is marked "B. M." Not only is this starting-point called a bench mark, but all permanent points which the leveler may establish along the line for future reference are called bench marks. They are marked and located as follows:

In the note-book there must be a full and clear description of each one of these bench marks in that part of the book where the B. Ms. occur in the regular line of the notes. It is a good plan also to leave a few pages blank in the back of the level-book, and on these pages copy all the B. Ms. in their order, with the number, description, and elevation of each. In getting a B. M. in the field the object is to get some firm point which cannot be moved, and is so situated that it may be readily found again. In running through a wooded country the most common method of making a B. M. is to take some large prominent tree and chop a place on the root, as shown in Plate XXII, fig. 7, and drive a tack in the top of the point. Then the point and all around it should be marked over with keel. On the side of the tree at a convenient height to be readily seen, and on the side next to the line a large "blaze" should be made, and on this blaze should be marked clearly with keel the letters B. M., the number of the B. M., and its elevation, as shown.

The objection to using the point of a ledge of rock, etc., is the difficulty of so marking and distinguishing the point used that it can readily be found again. In running through towns or cities, bench marks can be established on the corners of foundation walls, copings, etc. Care should always be taken to have the number and elevation of each bench mark clearly marked near it.

In running a line of levels on preliminary surveys, B. Ms. should always be established as often as every 2,000 ft. This distance apart of the B. Ms. depends, of course, to a great extent upon the nature of the country.

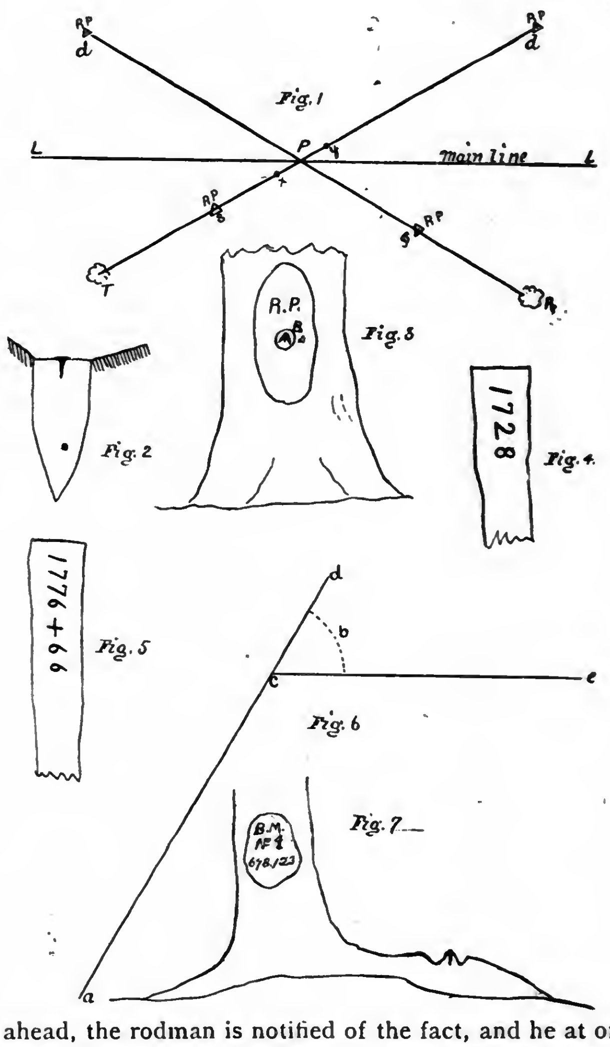
The leveler proceeds with his work as follows: Having a starting-point, or B. M., he sets up his level at a proper distance from it and levels its telescope. The rod is held on the B. M. and the telescope sighted on it, and the point on the rod where it is cut by the horizontal hair of the telescope is noted in the note-book.

This is called a plus (+) or back-sight. Now the distance from the bottom of the rod or the B. M. to the point where the rod is cut by the horizontal hair, is the distance that the center of the telescope is above the B. M., and this distance or reading on the rod added to the elevation of the B. M. gives the height of the instrument.

Having the height of the instrument, sights may be taken on the different stations. These are the minus (—), or fore-sights, and by subtracting the fore-sight of each station from the instrument height will give the height or elevation of each station.

When as many stations as possible have been taken from one position of the instrument, and it is desired to move

PLATE XXII



it ahead, the rodman is notified of the fact, and he at once takes a "turning-point." This turning-point is merely a firm point, which may be a bench mark, a station, or a special point. As it is only to be used once, there is no need of locating or describing it in any way in the note-book, beyond the fact that such a reading on the rod is a plus (+) reading or a minus (—) reading on a turning-point.

When the rodman has the rod on the turning-point the leveler obtains the elevation of it the same as one of the stations. He then moves ahead or to any convenient position and sets up his level and obtains the height of his instrument by taking a reading on the rod, still held on the

turning-point, and adding this reading to the elevation of the turning-point. The rodman must use the greatest care that the rod is held in exactly the same place for the plus as for the minus sight.

In all leveling the leveler should read his own rod through the telescope. When taking the height of stations these readings need only be taken to the nearest hundredth of a foot. But on bench marks and turning-points the readings must be taken to the thousandth of a foot, and the target and vernier scale should be used. The reason of using so much more care on turning-points than upon stations is this: Any error made in taking the elevation of a station is not carried beyond that station, and if it is of any amount can be detected at once when the profile is made, while any error made in either the plus or minus readings or the elevation of a turning-point is carried on in every elevation that is afterward taken, and if much care is not taken the sum of a number of these errors will amount to a great deal in the end of a long line of levels.

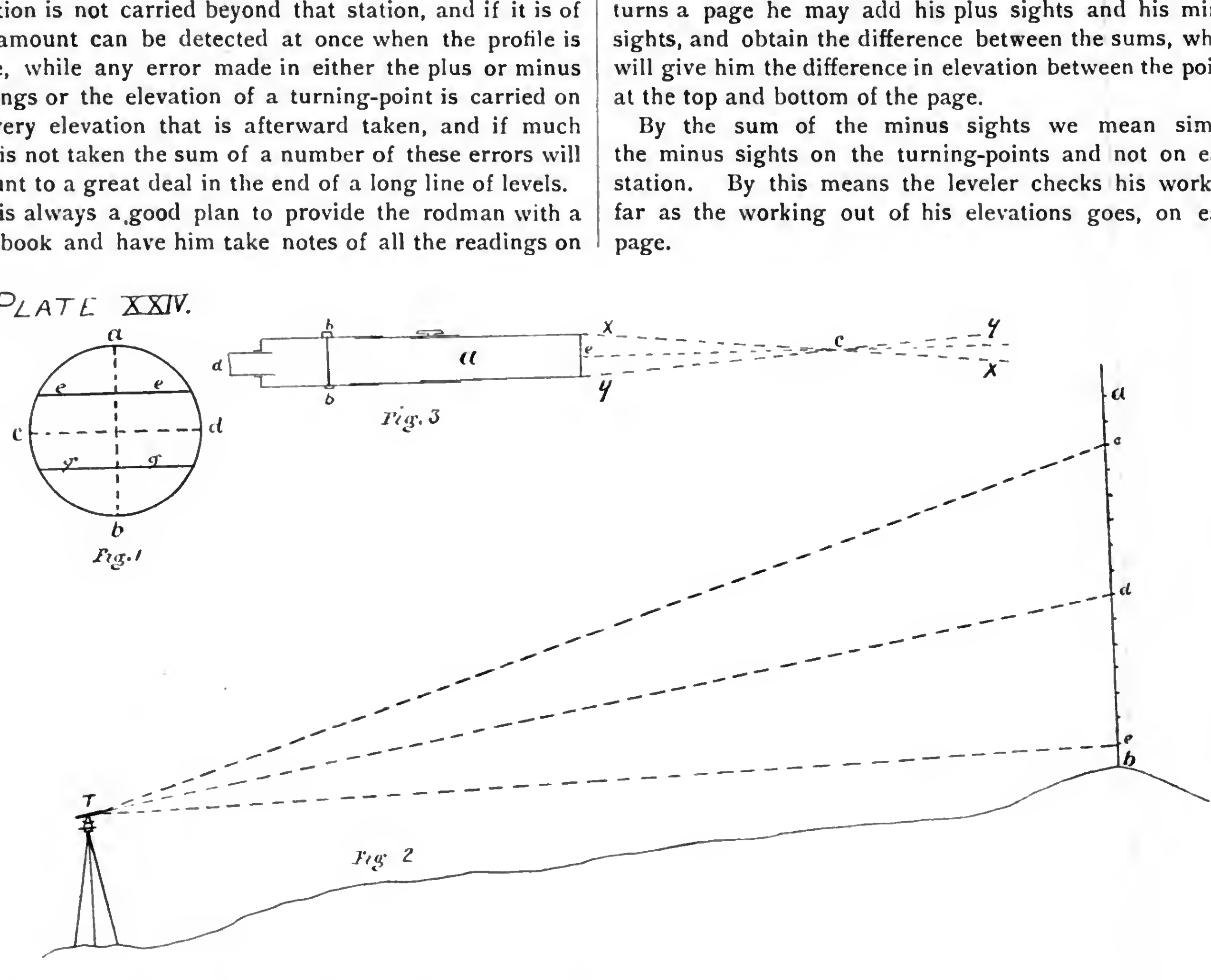
It is always a good plan to provide the rodman with a note-book and have him take notes of all the readings on

When time will permit, the line of levels should be checked by the work being gone over a second time and the elevations simply of the bench marks taken.

In the field the leveler should always work out his turning-points and as much else as possible. When the party returns to camp at night the leveler should work up all his notes, and make the profile of the line he has gone over during the day. When this has been done the Chief of Party carefully examines it as regards grade and the amount of work to be done in construction. In keeping the level notes one or two lines should be left blank at the bottom of each page, so that always before the leveler turns a page he may add his plus sights and his minus sights, and obtain the difference between the sums, which will give him the difference in elevation between the points at the top and bottom of the page.

By the sum of the minus sights we mean simply the minus sights on the turning-points and not on each station. By this means the leveler checks his work as far as the working out of his elevations goes, on each page.

PLATE XXIV.



bench marks and turning-points, and in this way serve as a check, to a certain extent, on the notes of the leveler.

The rodman must always take much care to hold his rod vertically in the direction of the level, because if the rod is inclined either toward or away from the level, the reading taken will be too great.

A good plan on turning-points and on other points where much accuracy is needed is to have the rodman slowly swing the rod toward and from the level, moving the upper end while keeping the lower end on the required point. The leveler will then take for his reading the lowest point on the rod cut by the horizontal hair, as this will be the point when the rod is vertical. There is also a disk level made, which the rodman holds in his hand against the side of the rod, and by means of which the rod can be held perfectly vertical. In holding the rod the rodman must take care not to cover the face of the rod with his fingers, but should always hold the rod in both hands and keep his fingers on the sides of the rod.

CHAPTER XIII.

STADIA SURVEYING.

With regard to what follows upon the use of the STADIA, let us say that we have only applied it to railroad surveying, and in its most elementary form. The first requisite is an explanation of what the stadia is.

In the telescope of any transit there are, as we have shown, two hairs or very fine platinum wires which cross each other at right angles, one of them being vertical and the other horizontal, as shown in Plate XXIV, fig. 1, which represents the end of a telescope. The two lines *a b* and *c d* represent the cross-hairs, and *e e* and *g g* represent the stadia wires. These are two horizontal wires placed one above and one below the horizontal cross-hair, and at equal distances from it.

If these stadia wires are so arranged that they can be moved and thus set at any required distance from the cross-hair *c d*, it is called a "movable stadia," and when the wires cannot be so moved, a "fixed stadia."

The object of these two wires is as follows: If we look through the telescope at a "stadia rod" (Plate XXIV, fig. 2), which is held the same as a level rod, we will see that a certain distance on the rod is intercepted between the stadia wires. If the rod is brought nearer the telescope, this intercepted distance on the rod becomes less, and as the rod is removed from the telescope the intercepted space becomes greater.

In Plate XXIV, fig. 3, let the lines *x x* and *y y* represent the lines of sight as bounded by the stadia wires; it will be seen that these two lines cross each other at *c*, after which they continue to diverge. The distance from the object-glass *e* to the point *c* is called the focal distance of the telescope, and is always equal to the distance from *e* to the stadia wires *b b*.

If a stadia rod be held at *c* there will be no space intercepted by the wires. Now move the rod any distance, say 100 ft., from *c*, and have it carefully held there. Then set the wires so that they shall intercept exactly 1 ft. on the rod; we can then measure the distance of the rod from the instrument up to 1,000 ft. with a rod 10 ft. long, and a greater distance with a longer rod. Thus if, when the rod is 100 ft. from *c* the wires intercept 1 ft., then with the rod at 200 ft. from *c* the wires will intercept 2 ft., and when the wires intercept 7.5 ft. on the rod, it will be just 750 ft. from *c*, and so on. The transit gives the direction of each of these lines, either by means of direct measurement of the angles, or by the magnetic needle. We can thus see how, without actually measuring on the ground, both the length and direction of any line on the ground may be obtained by means of the stadia.

So far we have considered the ground level and the telescope of the transit horizontal, thus making the rod vertical and at right angles to the center line of the telescope. This, however, is very seldom the case.

To take the distance of the rod from the transit directly from the distance on the rod intercepted by the stadia wires, the rod must always be at right angles to the center line of the telescope. In running through a rough country this would often be impossible, and it is necessary to measure the vertical angle of depression or elevation, as the point on which the rod is held is higher or lower than the point over which the transit is set up. In order to obtain the elevation of these points, tables have been prepared from which the actual horizontal and vertical distances of any point can be taken when the vertical angle and the distance on the rod between the stadia wires are known, the rod in every case being held vertical.

The vertical angle and the reading on the rod do not give directly either the elevation of the point where the rod is held or its horizontal distance from the transit, for the reason that the rod is held vertically and not at right angles with the center line of the telescope. But by means of these two readings we can take both the horizontal distance and elevation of the point from prepared tables.

From the foregoing explanation one can fully understand the many advantages possessed by the stadia method over the transit and level on preliminary work. One man does the work of two with the instruments (transitman and leveler), and the number of rodmen he can use and the rapidity with which he can get over the ground depends entirely upon the character of the country and the experience and personality of the stadiaman.

Each rodman should carry a small hatchet with which to make plugs to mark the line, and while one rodman holds the rod for points along the main line, one or more rodmen can be out on each side in order that the topography may be taken at the same time.

Stadia – Preliminary.						Notes.
Object.	Azimuth	Distance	Vertical Angle.	Difference of Elevation	Elevation above datum	Remarks.
Height of Inst.						
Elevation ⊡						

PLATE XXV.

The stadiaman must use the greatest care in keeping his notes in order not to get the different points confounded. Plate XXV is a sample page of a blank for the field notes of a stadia survey.

In the transit to be used for stadia work the following features are necessary to insure accurate work: The horizontal circle should be graduated from 0 to 360° in the direction of the hands of a watch, as then the azimuths of the different lines can be read in one direction. By the azimuth is meant the angle of the line with the true north-and-south line.

There should be an arc of the vertical circle rigidly attached to the telescope, as so much depends upon the vertical angles. The telescope should be inverting. The stadia wires should be fixed. The horizontal circle should read to 30 seconds.

Every instrument should have a solar attachment. The best solar attachment is made by Fauth & Co., Washington.

This can be screwed on to any transit, and is by far the most simple and the least liable to get out of order. The object of this solar attachment is to obtain quickly the true meridian. The only thing necessary to know is the declination of the sun. With a table showing this, one solar observation without any calculation will give the true meridian.

In many cases this can be obtained with accuracy by the needle, knowing the declination of the needle. But in some localities this is impossible, owing to local deposits, which render the needle unreliable.

The manner of making a preliminary survey with the stadia is as follows: The transit is set up over the starting-point and leveled. The vernier is brought to zero on the horizontal circle. Then set the instrument so that the telescope points N. and S. Unclamp the top plate and the instrument is ready for work. With the stadia rod take the height of the instrument—that is, the height above the ground of the center of the telescope. Then send the rodman to the next point to be taken on the main line, and have him drive a plug there. He then holds his rod on this plug with the edge toward the transit, and the transitman, turning only the top part of the instrument, sights on this rod and clamps the two plates together. Then, reading the angle on the horizontal plates, he has the azimuth of the line or the angle which that line makes with a N. and S. line.

The rod is then turned face to the transit, and the telescope is raised and lowered until the central horizontal cross-hair cuts it at the point of the height of the instrument. Then the reading is taken of the distance on the rod that is included between the stadia hairs, and the vertical angle, as denoted by the vertical circle, is read.

These are all noted in the note-book. We then have the three dimensions of the new point that are required.

1. Its direction from the preceding point by means of its azimuth.

2. Its distance from the preceding point by means of the distance intercepted on the rod by the stadia wires.

3. The relative elevation of the point as compared with the preceding point by means of the vertical angle.

The distance and elevation are not taken directly from the reading of the rod and the vertical angle, but must be deduced from these readings by means of properly constructed diagrams or tables.

The best diagram is the one that comes with "Topographical Surveying," by J. B. Johnson, published by John Wiley & Sons, and the best tables for the reductions of stadia readings are in the same book.

After the next point in the center line has been located, then sights are taken on each side to all the points which are required, such as houses, line fences, rivers, streams, and sufficient readings taken on the ground to locate the contour lines. Everything can be taken that is necessary to have on the map of the country in order to make a paper location. The rodmen hold the rods on all these points, but no plugs need be put in. Each point upon which a reading is taken must be fully described in the notes, so that there shall be no mistake. When readings have been taken on all the desired points from one station or point, the transit is moved on to the succeeding one and set up the same as before, and the height of the instrument taken. Then the telescope is sighted back on to the last point, and the vertical angle and the azimuth of that line taken. This serves as a check on the work of the center line. Then another point is put in ahead, and the work proceeds as before.

CHAPTER XIV.

TOPOGRAPHY.

Before explaining the work of the TOPOGRAPHER, it will be necessary to explain and illustrate what is meant by "contour lines" and "contour maps," as it is the data from which these are made which the topographer obtains in the field.

To illustrate what contour lines are, Plate XXVI is given. In this plate let fig. 1 represent a section of a tin dish for baking cakes; *a a* are the sides of the dish, and *c* the tube which comes up through the center.

In fig. 2 the heavy lines represent a plan of the dish, the parts in the two figures being lettered alike.

We set the dish bottom down on a table, and pour in water until it is an inch deep in the dish; then with some

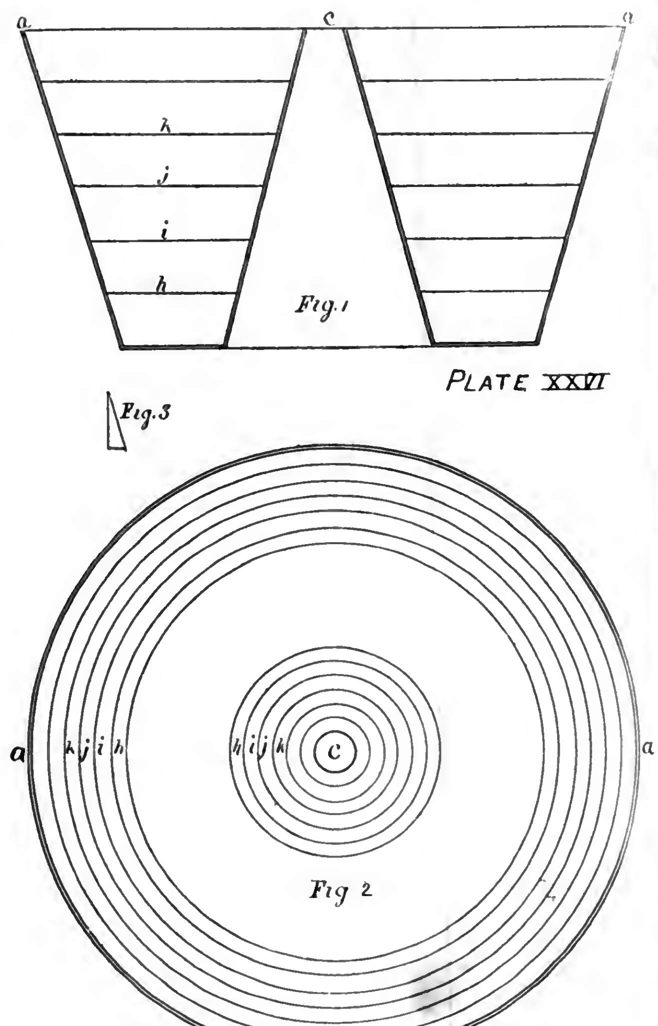


PLATE XXVI

sharp-pointed instrument like a needle we mark around the inside of the dish just at the water-line *h*, also on the center tube. Then again pour in water until it is an inch deeper, and mark this water-line the same as before.

In a like manner continue increasing the depth of the water inch by inch and marking the water-line each time, until the top of the dish is reached. Then turn all the water out, and we have the lines *h, i, j, k*, etc., marked on the dish. Each of these lines is horizontal throughout, and therefore any two of them are the same distance apart vertically.

These lines are "contour lines"—that is, they are level lines following the side of the dish.

Now, to make a "contour map" or plan of this dish we have only to project the lines *h, i, j, k*, etc., upon the plan

On railroad work, where the amount of ground surveyed is comparatively small and a very close representation of the surface of the ground is required, the contours are put in every 10 or 20 ft. apart vertically.

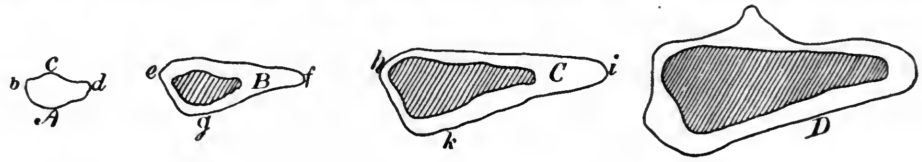
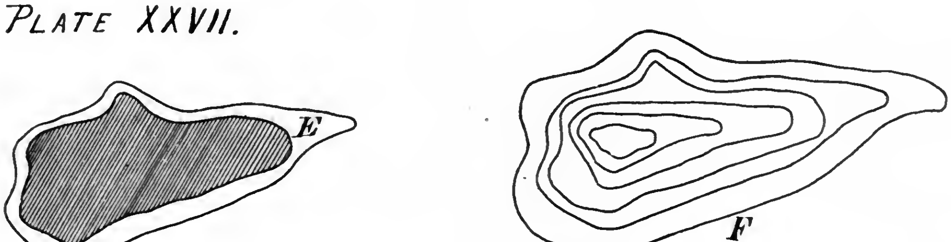


PLATE XXVII.



of the dish, fig. 2, where they are shown by the lighter lines, and thus make fig. 2 a contour map of the dish—that is, it is a plan of the dish so finished that every vertical change in its surface is shown, such as the slope of the sides and the center tube, by means of the contour lines. To get the slope of the side of the dish from the contour map, Plate XXVI, fig. 2, we know that vertically these contours are one inch apart, which distance can be taken as a perpendicular of a right-angled triangle, and the distance *h i*, fig. 2, as the base of the triangle, fig. 3; then the hypothenuse will represent the length and inclination of the side of the dish between any two contours.

Now, as far as the dish is concerned, which has been used as an illustration, it is clear what is meant by contour lines and contour maps.

Now, in the place of the dish, let us take a valley *A*, Plate XXVII, surrounded by land. We will suppose that this valley has water in it 10 ft. deep in the center, and that the lake thus formed would take the shape *b c d*. The water-line on the shore of this lake would be a contour line. Now, imagine the water to rise 10 ft., and we would have a lake of the form *B*, and *e f g* would be a contour line.

Let the water rise again 10 ft., and we have the lake *C* and the contour line *h i k*, and so on. As the water rises we get larger lakes and different shaped contour lines.

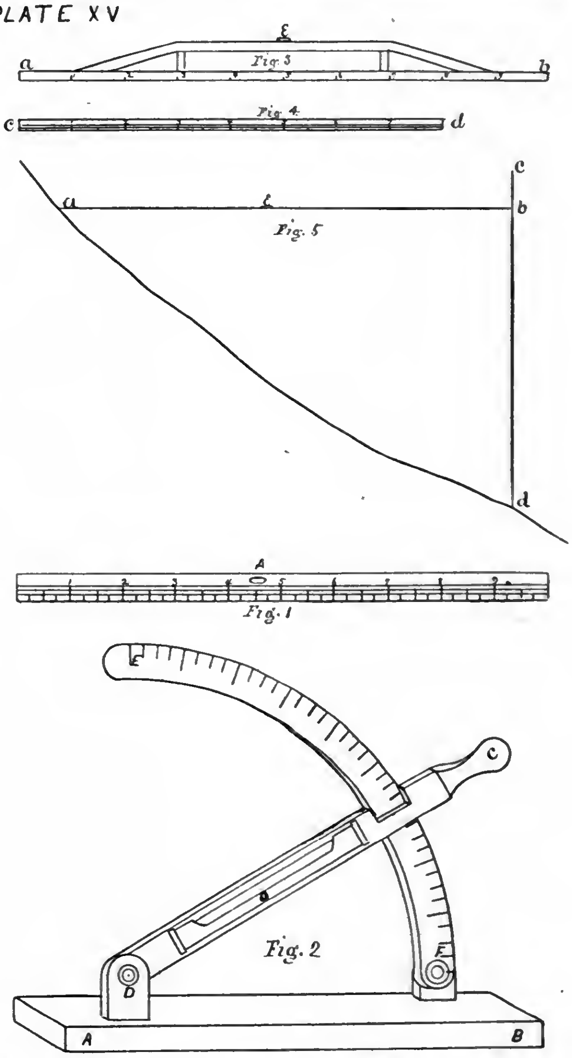
All of these lines that are marked by the water's edge must be contour lines, as the surface of still water is always horizontal, and by plotting these lines one on top of the other in their relative horizontal position, we have the contour map of the valley *F*. *Therefore a contour line is a broken or curved line following the surface of the ground, every point of which is in the same horizontal plane.*

When these lines are plotted on the map of the country in their proper positions we have a contour map, and by means of this map can understand exactly every change in the surface of the ground. The vertical distance between the contours will depend upon the character of the country and the scale upon which the work is done.

In Government work, where thousands of square miles are surveyed and the maps plotted to a very small scale, the contours are often 100 or 200 ft. apart vertically.

Having now fully explained what contour lines and maps are, we will return to the duties of the topographer. These duties are to procure in the field such data that when the line run by the transitman has been plotted, he

PLATE XV



can put in the contour lines and all the prominent topographical features for the required distance on each side of this line.

When, owing to the character of the country, the contour lines are required for only a comparatively short distance of from 100 to 200 ft. on each side of the transit line, the data required are taken by the topographer in the following manner:

The instruments used are the clinometer and board rod, or cross-section rods, which were shown in Plate VX, fig. 1 (which is reproduced on page 109), and which were described on pages 11 and 12.

In using the clinometer and the board rod one end of the rod is placed on the ground at a station and as nearly at right angles with the main line as can be judged quickly by the eye. The clinometer is then placed on the rod and the angle of slope measured. The rod is held by one of the assistants and the clinometer by the other. When the angle of the slope has been taken, the assistants measure, with either the rod or a tape-line, the distance that slope continues. At a point where there is a change of slope the rod is put on the ground again and the angle of the new slope taken, and so on until the distance desired, each side of the main line, has been taken.

The topographer keeps notes of each angle of slope and the length of each slope, using plus signs for the angles of the slope where the ground rises and minus signs where the ground falls, and writing the length of each slope under its proper angle. The principal objection to this method is the difficulty of plotting the contours in the field, and wherever the notes only are taken in the field and then plotted in the office there is great chance of error.

The method of obtaining the required data by means of cross-section rods is as follows:

One end of the rod *a b* (Plate XV, fig. 3) is held at the station, resting on the ground, when the ground slopes down, and at the station, with the other end on the ground, when the ground slopes up. The rod is then brought to a level by means of the bubble *e*, and the vertical distance *b d* is measured by means of the other rod *c d*. The rod *a b* is then moved to *d*, and the same operation performed again, and so on until the required distance has been taken.

(TO BE CONTINUED.)

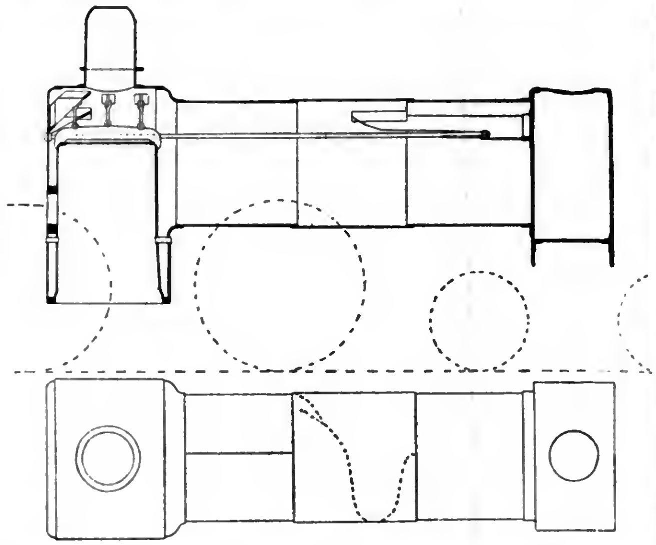
LOCOMOTIVE BOILER EXPLOSIONS ON BRITISH RAILROADS.

(*Continued from page 70.*)

WE continue below the condensed statements of the Inspectors of the Board of Trade of the results of their investigations into accidents on British railroads resulting from the explosion of locomotive boilers.

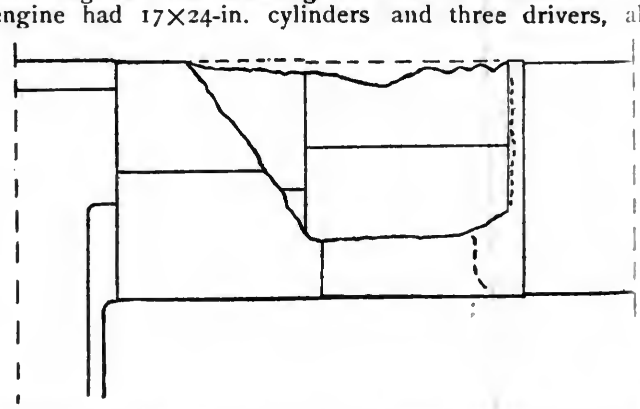
INSPECTORS' REPORTS.

September 24, 1878, the engine of a mixed passenger and goods train on the Great North of Scotland line exploded its boiler at Boat of Garten, just after the train had stopped at that station. One man on the engine was badly hurt, and two others escaped without any serious injury. The front plate of the barrel of the boiler was blown away about 600 ft. from the train, the middle plates torn across, and the frame and machinery of the locomotive badly damaged, the axles being bent and one wheel broken off from the axle. The engine was 15 years old, and had run about 352,000 miles in all. It was thoroughly repaired about a year before the explosion, when the boiler was tested up to 170 lbs.; the safety-valves were adjusted to 140 lbs. The engine had cylinders 16×22 in., four driving-wheels, and a four-wheeled truck. The barrel of the boiler was 45 in. diameter and 11 ft. long, and was formed of six plates, three in the length and two in circumference. The longitudinal seams overlapped $3\frac{1}{2}$ in. and were double riveted; the vertical seams $2\frac{1}{4}$ in., and were single riveted. The longitudinal seams of the middle plates were at the center



of the boiler, those of the end plates at the top and bottom. The plates were originally $\frac{7}{16}$ in. thick. The accompanying diagrams show a section and plan of the barrel of the boiler, the principal braces being shown on the sectional view. The dotted lines on the plan show the line of fracture. In this case the Inspector says: "There is very little reason to doubt that the explosion commenced along the bottom seam of the two front plates next the fire-box, grooving being very evident along the course of the seams in the left plate. The grooving was deepest near the center of the seam, leaving at points a very slight thickness of metal; otherwise the plates were in good order and were not much worn or pitted. The practice of making locomotive boilers with horizontal seams below the water line is now almost abandoned, on account of the liability of these seams to become grooved without a possibility of detection except when new tubes are put in or a leakage occurs."

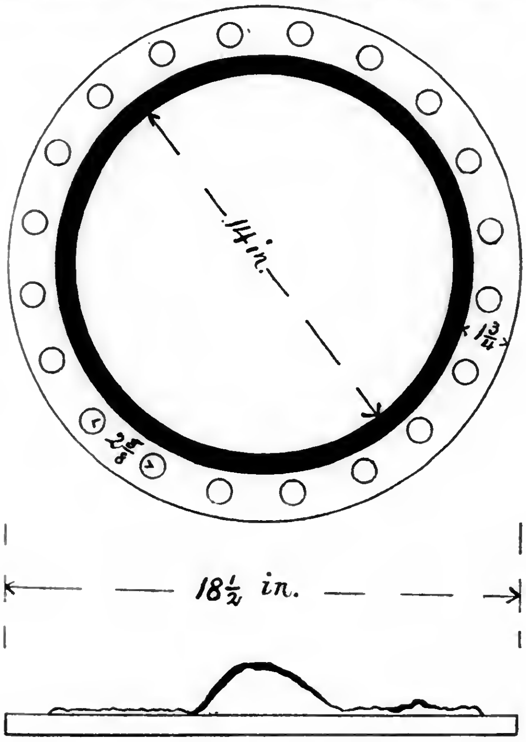
November 24, 1878, the boiler of the locomotive of a freight train on the Northeastern line exploded just after the train had stopped at Blaydon. Three men on the engine were badly hurt. The barrel of the boiler was almost destroyed, nearly the whole of the middle top plate, with portions of other plates, being blown away, while some other plates were cracked. The accompanying sketch shows the portion of the boiler which was damaged, the irregular lines showing the lines of fracture. The engine had 17×24-in. cylinders and three drivers, all



coupled. The barrel of the boiler was composed of plates of Lowmoor iron, 3 in. the length and 2 in. the circumference. All the plates were $\frac{7}{16}$ in. thick, all the joints double riveted. It was six years old, and had been thoroughly repaired and new tubes put in about a year before the explosion, when the boiler was tested with water up to 220 lbs. and with steam to 140 lbs. The Inspector found that the explosion commenced at a flaw near the top of the

lower middle plate. This flaw extended nearly the whole breadth of the middle plate, in parts leaving only a skin of sound metal. This fracture thus commenced ran through the joint next the front plates, then across the upper middle and rear plates. It is probable that the flaw referred to was due to some original defect in the plate, which had not shown itself when the boiler was examined.

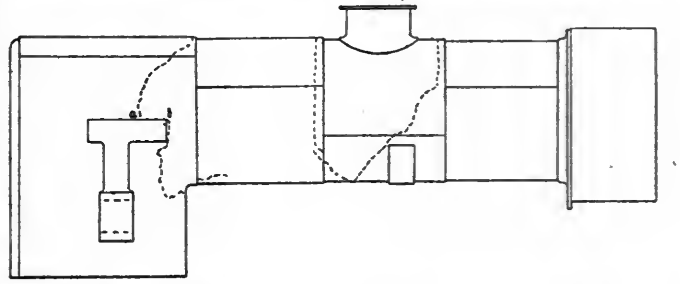
November 30, 1878, as a passenger train on the Great Western line was just starting from Penzance, the dome of the engine was blown off. No persons were hurt, but the cast-iron dome with its brass cover was blown into the air and came down through the roof of the station, while a small piece of the brass cover fell in the road 250 ft. away. The dome which gave way was 15 in. diameter, of cast iron ½ in. thick; it broke at the flange. The accompanying sketch shows a transverse section of the dome and a side view, showing the line of breakage. Subsequent examination showed a flaw in the metal about 9 in. long, extending nearly through, and another about 1 in. long extending about one-half through the iron. These



flaws and the break caused by the dome being blown away made a clean and nearly level fracture all around the flange. It appears that the engine was repaired about three months before; at that time the dome leaked in front, and it was thought that the leak was at one of the 20 studs by which it was fastened to the boiler. Three studs were renewed, and the boiler being tested with 120 lbs. pressure, no leak was noticed. The dome again leaked about a month before the explosion, when the joint was refitted. It is to be noted that the use of cast iron for the domes of boilers was an old practice, and at the time of this explosion had been abandoned, wrought iron being used on all new engines. The engine in this case was 26 years old. It was a tank engine with 17×24-in. cylinders and six wheels 5 ft. diameter.

September 9, 1879, the boiler of the engine of a coal train on the Northeastern Railway exploded just after the train had started from Leamside station. The engineer and firemen were badly hurt. The barrel was torn to pieces, and a number of the tubes were torn out; pieces of the iron were picked up 1,000 and 1,200 ft. distant. The engine had 17×24-in. cylinders and six wheels, all coupled. It was built in 1871, and had run 250,000 miles. The plates were all Lowmoor iron $\frac{7}{16}$ in. thick; there were six in the barrel of the boiler; the horizontal joints were all lap joints. The usual working pressure was 130 lbs. There was no reason to suspect tampering with the safety valves or unusually high pressure. The fracture commenced on the right side, and there was some grooving along the line marked *a b* in the accompanying diagram, where a hanging stay was attached to the outer shell; with the exception of this slight grooving the edges of the plates where broken showed no signs of deterioration. The Inspector says:

"The boiler had never been tested since it commenced running, when it had been submitted to the usual hydraulic pressure of 220 lbs. to the square inch, nor had an opportunity offered for making any internal examination since



October, 1872. The Locomotive Superintendent informed me that the reason this boiler had not been tested was that it was a comparatively new one, and had shown no symptoms of deterioration, though it would in course of a short time have been tested.

"It appears to me that seven or eight years of hard running is too long a time for any boiler to work without being tested or internally examined, and that it would be only wise to establish a rule that all boilers should be tested at regularly recurring periods of considerably shorter duration.

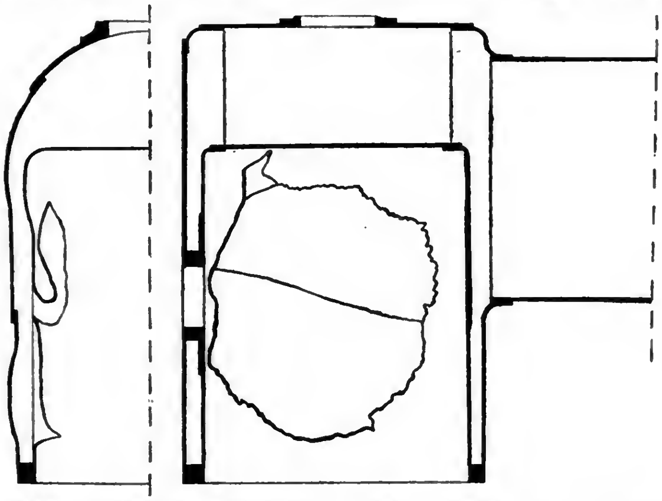
"The method, too, by which this boiler was supported—viz., by rigid connections to the side of the outer shell of the fire-box, thereby interfering with the free expansion and contraction of the boiler lengthways, is now but rarely used."

September 16, 1879, the boiler of the engine of a freight train on the Northeastern Railway exploded while the train was between Headingley and Horsforth. The train at the time was running up a grade of 1 in 100 at a speed of about 10 miles an hour. The engineer was slightly hurt. This was one of the rare cases of a boiler exploding while the locomotive was in motion. Nearly two-thirds of the barrel of the boiler was blown away to some distance, the frames of the engine were bent, and the running gear very badly damaged; the crank axle was broken off at one of the angles. The engine had 16×24-in. cylinders with six wheels 57 in. diameter, all coupled. The boiler was 46 in. diameter of barrel and 10½ ft. long. It was originally built in 1848, and the engine had run 665,000 miles. The barrel originally consisted of six plates $\frac{7}{16}$ in. thick, three in the length and two in the circumference. These did not break joints. The horizontal joints were opposite each other about one-half way up the barrel; the vertical joints were lap joints. The boiler was repaired in December, 1878, when the bottom plate was patched and a new piece of plate fitted in the full length of the original plate, but only 30 in. wide, thus making the lower half of the boiler of three narrow plates. So far as could be ascertained, the rest of the plates were those originally put in in 1848.

The Inspector believes that the explosion was caused by the giving way of the side and bottom plates of the boiler, in which the thickness of metal had been reduced to ¼ in., and in one place to ⅛ in., by corrosion. The explosion seems to have started along the joint between the old and new plates mentioned above. Besides the corrosion some of the old plates showed signs of considerable brittleness. The Inspector also thinks that it is not right to continue in active use boilers as old as this one was; he also doubts the correctness of the plan of riveting new plates to old ones. Fortunately it is an unusual thing to find boilers of so great age still at work.

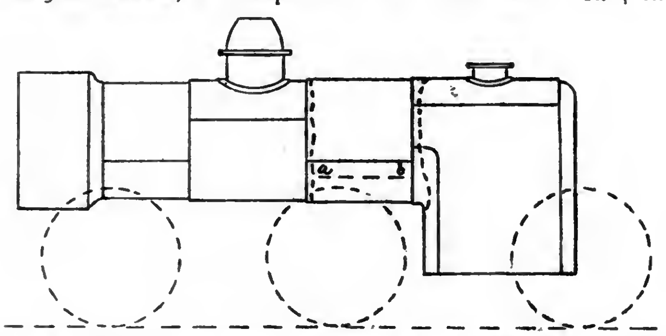
September 25, 1879, an engine of a passenger train on the London, Brighton & South Coast line exploded its boiler just after the train had stopped at Lewes station. The engineer was killed and two other men badly hurt. At the time of the explosion the engine was taking water

from the tank, and its force lifted it from the rails and threw it over on the platform of the station. The explosion was caused by the breaking of the left side plate of the fire-box, which gave way along the horizontal line between the second and third rows of rivets from the bottom of the box. The plate was torn from the stay-bolts and the piece, extending nearly the whole length of the fire-box, was folded over against the inside upper part of the sheet. The nature of the break is shown in the accompanying diagram, which gives a longitudinal section and a half cross-section of the fire-box. The outside sheet was bulged out of shape as shown. The engine was a



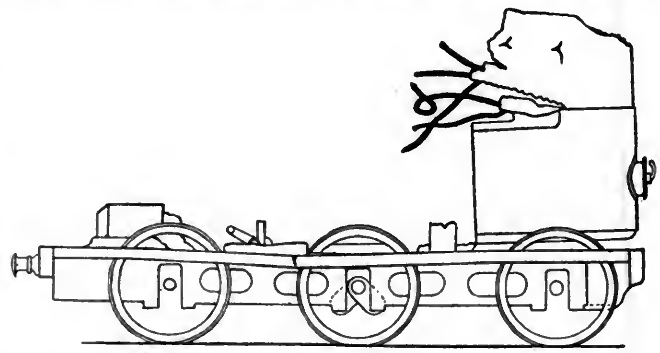
passenger engine with four coupled drivers 6 ft. in diameter, and leading wheels 4 ft. in diameter; the cylinders were 16×20 in. It was 15 years old, and in 1870 had been repaired and a new fire-box and tubes put in. Since receiving the new fire-box it had run 305,000 miles. The engine had been in the shops only a few days before the explosion in consequence of the tubes leaking; and at that time the boiler-maker examined the boiler. At the investigation he stated that he had found the fire-box plates on the right side badly worn, but he had not reported this fact. The fire-box was of copper, the plates originally $\frac{7}{16}$ in. thick. The examination showed that at the point where the plate gave way it had been reduced to about $\frac{1}{16}$ in. The safety-valves were set at 120 lbs. This reduction of the copper sheet was quite sufficient to account for the explosion, though there was also evidence that plugs of waste had been jammed in between the spring-balances and the boiler, apparently for the purpose of increasing the pressure at which the safety-valves would blow off. There was no evidence, however, that the pressure had been above 120 lbs., and even at that pressure a copper plate only $\frac{1}{16}$ in. thick was liable to give way at any time.

January 26, 1880, the boiler of the engine of a freight train on the Northeastern Railway exploded while the train was standing on a siding at Silksworth. Two men were injured. The ring of the boiler barrel next the fire-box and part of the outer shell of the fire-box were completely torn away, the frames were bent, and the engine badly damaged. The engine had 17×24-in. cylinders and six 5-ft. wheels, all coupled. The barrel was 11 ft. 4 in.

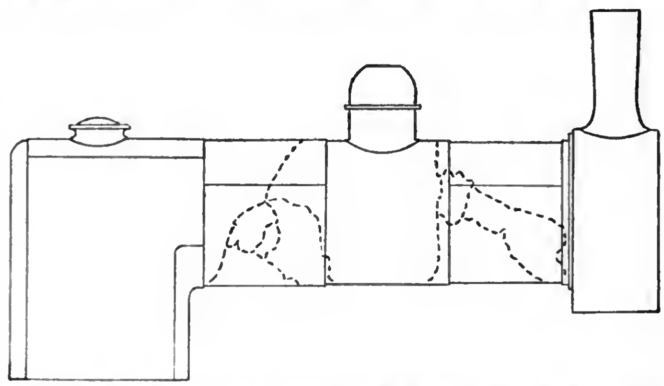


long and 50 in. diameter. It was of the telescope form, of iron plates $\frac{7}{16}$ in. thick, with all seams double riveted; the outer shell of the fire-box had plates $\frac{5}{8}$ in. thick. The engine was nine years old, had been repaired in 1875, and the boiler had been tested to 200 lbs. two years before the explosion. The safety-valves were set at 125 lbs., and just before the explosion steam was blowing off. The accompanying sketch shows the general form of the boiler, the dotted lines being lines of fracture, while the line *a b* shows the line of corrosion referred to below. Examination shows that on this line *a b* there was deep grooving in the lower plate along the seam, extending through almost its entire thickness. This was probably due to the proximity of the joint to the plate attached to the side of the fire-box, which rested on another plate attached to the frame. The bearing surface being considerable, a great deal of resistance was offered to expansion and contraction. The strains thus put upon the joint were probably the original cause of the grooving. There seems to be no doubt that the rupture started on this line.

On November 12, 1880, the boiler of the engine of a freight train on the Northeastern Railway exploded while the train was standing at Rainton Crossing. The engineer and fireman were both badly hurt. The barrel was completely blown away, leaving the engine, or the remains of it, in the condition shown in the accompanying diagram.



The second figure shows the boiler, the dotted lines giving the lines of fracture. The engine, which was six years old, had six coupled driving wheels. The boiler was of iron, the plates $\frac{7}{16}$ in. thick, the barrel being 50 in. in diameter. It was built up of three rings, each ring of one plate with ordinary lap joints, and a steam dome in the center of the middle ring. It had been repaired in 1878, $2\frac{1}{2}$ years before the explosion, when new stay-bolts were



put in the fire-box. At that time it had been tested up to 220 lbs.; the usual working pressure was 130 lbs. It had never, however, been carefully examined internally.

The Inspector says that the barrel was broken off in 11 pieces, which were scattered in every direction. From a careful examination there appears to be no reason to doubt that the cause of the explosion was top grooving along the horizontal joint of the middle plate. This joint was 15 in. below the water line, and was grooved more or less along the whole of its length, the sound metal being in parts not more than $\frac{1}{16}$ in. thick. The plate also was not of very good material. The Inspector says, in conclusion, that the explosion of this nearly new boiler raises several questions.

"1. Whether every boiler should not be submitted to internal inspection after running a certain number of miles, say 100,000.

"2. Whether boiler barrels should not be made with butt joints rather than lap joints, so as to insure their being

perfect cylinders, and thus to making contraction and expansion as uniform as possible for the joints of the barrel.

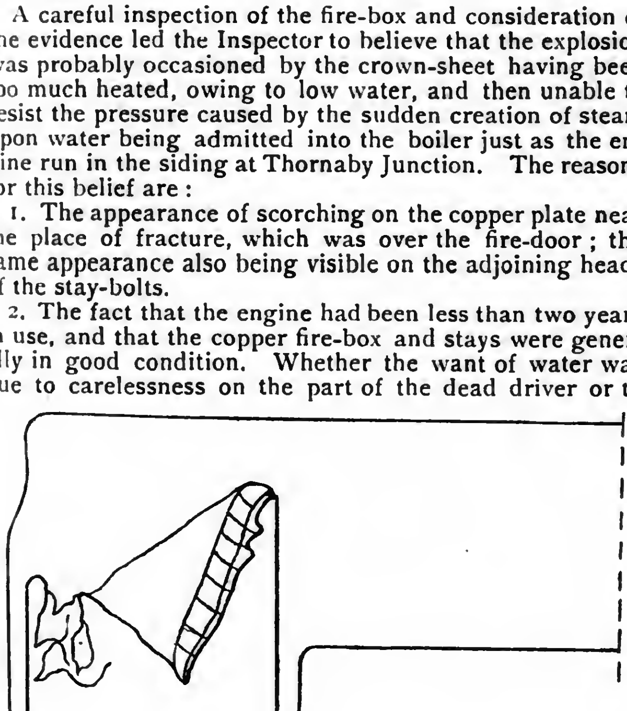
"3. Whether with boiler barrels made with one plate in each ring the joints should not be arranged in all cases so as to be above the water line."

December 26, 1881, as a freight train on the North-eastern line was drawing into a siding behind a coal train at Thornaby Iron Works, the fire-box of the boiler exploded. The boiler was thrown forward and deposited on the fifth or sixth car from the rear of the coal train, striking as it passed the brake-van of the coal train, and setting it on fire. The wheels of the freight engine and its tender were thrown off the rails, and the cars of the freight train were thrown backward about 100 ft. along the track by the shock. Three men on the freight train and two on the coal train were killed. This engine was built at the company's shops in 1880, and was only about two years old at the time of the explosion. The fire-box, which exploded, was of copper and of the usual form, its internal dimensions being 4 ft. 5 in. long, 3 ft. 4 in. wide, and 5 ft. 10 in. high. It was made of copper plates ½ in. thick, and was stayed in the usual way with ⅞ in. copper bolts 4⅛ in. between centers, at the ends and sides. The crown-sheet was supported by seven crown-stays 4¾ in. between centers. there being in each crown-stay 10 wrought-iron bolts 1 in. in diameter and 4½ in. between centers. These stays were supported by hanging stays attached to the outer shell of the fire-box. A fusible plug was screwed into the center of the roof of the fire-box. The fire-box was provided with a brick arch or deflector. The safety-valves were set at 140 lbs. They had been cleaned and tested three weeks before the explosion. There was a glass gauge so arranged that no water would be visible in the glass unless there was about one inch of water above the top of the fire-box.

A careful inspection of the fire-box and consideration of the evidence led the Inspector to believe that the explosion was probably occasioned by the crown-sheet having been too much heated, owing to low water, and then unable to resist the pressure caused by the sudden creation of steam upon water being admitted into the boiler just as the engine run in the siding at Thornaby Junction. The reasons for this belief are:

1. The appearance of scorching on the copper plate near the place of fracture, which was over the fire-door; the same appearance also being visible on the adjoining heads of the stay-bolts.

2. The fact that the engine had been less than two years in use, and that the copper fire-box and stays were generally in good condition. Whether the want of water was due to carelessness on the part of the dead driver or to



some defect of the water-gauge having misled as to the height of water, it is not possible to say. The accompanying diagram shows the rear end of the boiler as it appeared after the explosion.

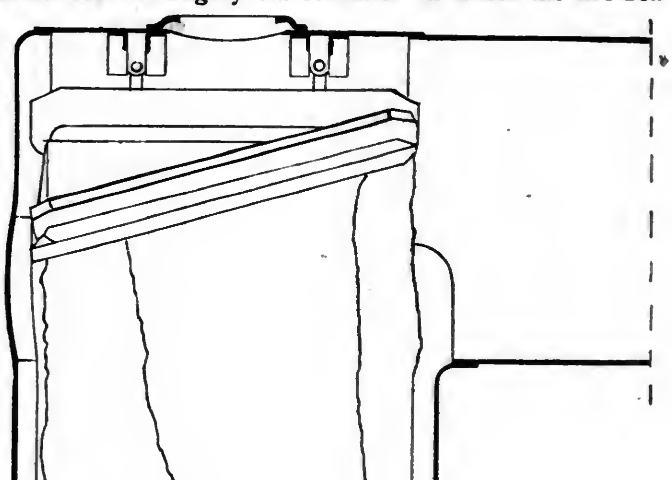
The comments of the Inspector on this accident are as follows:

"The difference of level between the top of the boiler and the crown of the copper fire-box, amounting only to about 13 in., was certainly small in the case of this engine, and would, of course, quickly allow the crown of the fire-box to become uncovered without very constant attention. I am not aware of the greatest difference of level which exists, but I know that some locomotive engineers keep down the crown of the fire-box 20 in. below the top of the boiler, and that 15 to 18 in. is a common difference of level. So small a difference as 13 in. should, as far as possible, be avoided.

"The failure of the lead plug (which had been removed from the fire-box by order of the Locomotive Superintendent soon after the explosion) to melt when the crown of the fire-box became heated appears to have been owing to the bottom surface of the lead having become covered with a hard incrustation. Some locomotive engineers think these plugs entirely untrustworthy; others, on the contrary, use them, but have them frequently renewed.

"The plug in the present instance had not been renewed for four or five months, the boiler-smith stating that there was no regular time for renewal. There can be no grave objection to the use of these plugs, and if their renewal is made peremptory at short intervals, when an engine is in the sheds for overhauling, there would be comparatively little fear of their not being in a state of efficiency in case of need."

February 10, 1882, the boiler of the engine of a freight train on the Great Eastern line exploded just after the train had stopped in front of the freight house at Bury St. Edmunds. The driver, fireman, and guard, who were all on the engine, were very badly scalded. The failure in this case was of the fire-box, which was destroyed: no fragments were thrown away. The force of the explosion lifted the rear end of the engine off the track and threw it across the opposite line; the coupling between the engine and tender was broken and the train thrown backward, the tender and a car being thrown from the track. The engine had four driving wheels and a four-wheeled truck; it was 17 years old, and had run 204,000 miles. In 1876, about 5½ years before, it had been supplied with a new boiler and fire-box. This boiler was made of Yorkshire iron ⅜ in. thick, except the tube-plate, which was ½ in. This boiler when new had been tested up to 240 lbs.; the usual working pressure was 140 lbs. In 1880, two years before, a new set of tubes had been put in, and at that time the fire-box was carefully examined, some slight repairs made, and some new stay-bolts put in. The accompanying sketch shows roughly the condition in which the fire-box

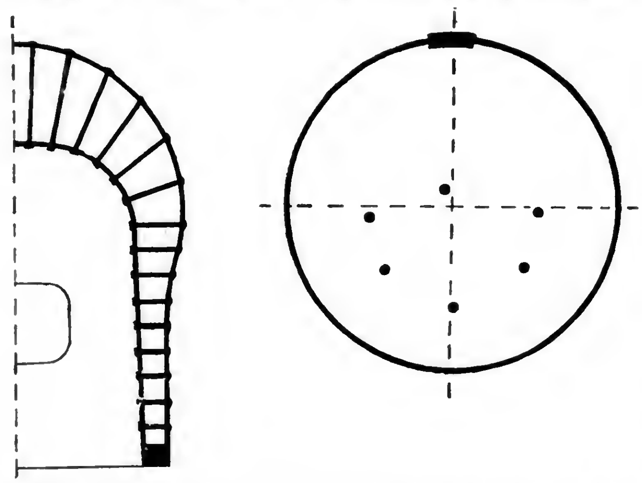


was left after the explosion. There were eight crown-bars, two of which were thrown down and left in the position shown in the sketch; the other six remained in their proper position. A portion of the tube-sheet and the side-sheet were folded round as shown.

The Inspector says that, from a careful consideration of the evidence and inspection of the fractured fire-box, there is little reason to doubt that the explosion was due to the defective condition of the copper stay-bolts. Three of these, a little below the center and near the forward end, were found to show old fractures. The fire-box evidently began to give way at this point by the steam pressure first bulging the copper plate, then stripping it away from the

unbroken stay-bolts, and at the same time breaking a number of them which appeared to be cracked. There is no reason to suppose that there was any excess of steam pressure. Three days before the engine-driver had reported that there was some leaking at the stay-bolts, and these leaks had been temporarily closed up by a boiler-maker, who reported to the foreman that the stay-bolts were getting into bad condition, and that a number of them required renewing. The Inspector blames the foreman for allowing the boiler to continue in service in this condition.

September 1, 1882, the boiler of the engine of a freight train on the North British Railway exploded near Dunbar just after the train had stopped at a water-tank to take water. The explosion killed the driver and fireman, and a third person unknown, who, it is supposed, had been riding on the engine without proper authority. The boiler was thrown by the explosion over on the opposite track, causing the wreck of a freight train which was approaching on that track. The engine was six years old, and had run 180,000 miles. It had received general repairs six months before; since that time it had been running, and there had been no reports made of anything wrong with the boiler. A slight examination of the fire-box had been made three days before, when it was reported all right. The results of the explosion were extraordinary in the complete destruction of the boiler and the distance to which many of the fragments were thrown. The principal force, apparently, was exerted to the left hand, a large piece from the left side of the barrel having fallen nearly 1,500 ft. away, while another piece was picked up 800 ft. away, somewhat in advance of the engine. Nothing was left standing above the level of the frame of the engine, which was much bent out on one side. The driving axle was broken. The fire-box was blown into three pieces, which were thrown in different directions. The smoke-box and smoke-stack were thrown forward about 300 ft. The safety-valves, it appears, were set at 137 lbs., and the evidence shows that they had been in good order a day before the explosion. The construction of the boiler and fire-box presented no special features. The accompanying diagram shows a section of the barrel of the boiler, which was 54 in. in diameter, and also a half section of the fire-box showing the position of the stay-bolts connecting the inside and outside shells. It will be noticed that the top of the fire-box was arched and that there were no crown-bars, the top-sheet being stayed directly to the outer shell. The barrel of the boiler was composed of two plates in its length, each plate making a complete ring, the joints being at the top of the boiler; they were butt joints with cover plates inside and out, with four rows of rivets through the cover plates. The boiler was provided with



the usual braces, the only exception being that at the time it was last repaired six of the tubes were taken out and were replaced by six longitudinal iron stays running from the front to the back tube-plate, and secured at each end by nuts screwed on. The position of these stays is shown in the cross-section of the barrel.

The Inspector says that the cause of this explosion is involved in obscurity. The engine was comparatively new, and the boiler appears to have been in good condition. The fact that all the men on the engine were killed makes it still more difficult to ascertain whether there was any special cause. A careful examination failed to show any corrosion of plates or bad material sufficient to account for the accident. Some pitting was observed, but very slight, and of the broken stay-bolts very few appeared to be at all defective. The only theory which he is able to suggest was that the explosion was caused by the sudden generation of steam of very high pressure. The fire-box crown-sheet, however, did not show any signs of scorching or of low water, and this theory must be accepted with some caution, especially as there was a fusible plug in the crown-sheet of the fire-box which was nearly new, and which showed no signs of melting.

The returns of the companies for the year 1878, as summed up in the report of the Board of Trade, show that there were 10 cases of bursting of boilers or tubes of locomotives, by which 14 persons—all railroad employés—were injured. Three of these cases were specially examined into and reported on, as shown above; the others, apparently, were slight cases of not sufficient importance to require investigation.

In the year 1879, the Board of Trade returns showed that there were five accidents from bursting of boilers and tubes, by which one person was killed and eight hurt. Two of these were of slight importance; the other three were sufficiently serious to require investigation, and the reports are given above.

For the year 1880 the reports mention four cases of explosions of boilers or collapse of tubes, in which one person was killed and five hurt. Two only of them were investigated, the rest being of slight importance.

During the year 1881 there were reported seven cases of the bursting of boilers and tubes of engines, by which five employés of the railroad companies were killed and four injured. This year only one of these cases was inquired into—the explosion in which five employés were killed; the others were of slight consequence, apparently, as no investigation was made.

In 1882 two cases were investigated and reported on, out of a total of four reported, in which three persons were killed and five injured. The other two cases only were of importance.

(TO BE CONTINUED.)

A New English Torpedo Boat.

(From the London *Engineering*.)

ATTENTION has been so much concentrated of late on first-class torpedo boats, which have been constantly growing in size and power, that the smaller types of these craft have been almost forgotten. Indeed, in many quarters it was thought that the second-class boats had had their day, or rather (as those who hold this opinion would put it) that the craze for them was past. There was a good deal of reason for this opinion; for the old second-class boats were, as is well known, designed especially for hoisting on board ship, a position in which they are a consummate nuisance. The counterbalancing advantages to be expected from these craft in war are, at the least, problematical, and in peace time they are absolutely no good at all. The chief drawback is their unseaworthiness, and this is due greatly to their want of stability. The later vessels built are 63 ft. long and 7 ft. to 7 ft. 3 in. wide. It is true that on some few occasions second-class torpedo boats have been out in pretty rough weather for craft of their size, but although they struggled through without foundering, a ride on their decks more resembled a passage on the back of a porpoise than the average notion of steam navigation.

It has hitherto been maintained that, in order to secure speed it was necessary these boats should not exceed the breadth of beam heretofore accorded to them; and, as speed is considered of paramount importance, seaworthiness has had to give way. The Admiralty authorities have, however, not entirely supported this view of late, and a recent addition to the English Navy has proved that more could be done, both in the matter of speed and stability, than was before considered possible, within the limits of length necessary for a second-class boat. Messrs. Yarrow & Co., of Poplar, a short time back made a contract with the Admiralty to build a vessel which was to have higher speed and greater beam than the existing boats, and this without exceeding the limit of length prescribed by the exigencies of lifting and stowing on shipboard; as a matter of fact, the boat in question is 3 ft. shorter than her immediate predecessors, being only 60 ft. long over all, while she has a breadth of 8 ft. 6 in.

One or two preliminary runs have been made during the last month or two, since the boat was completed, but the official trial was made the week before last with very satisfactory results. Before, however, we consider the boat's performance it will be well to give a few of the leading elements of her design.

No. 50 second-class torpedo boat—for this is another official designation of the craft—is, as already stated, 60 ft. long by 8 ft. 6 in. beam. She is flush decked, and has a freeboard of 3 ft. 6 in., which gives a good height above water. We lately had an opportunity of seeing the boat hauled up on the slip, and could not help admiring the skill with which the conflicting elements of speed and stability were combined in the model. The bilge is carried well down, and there is a good floor, and yet the entrance is fair and easy, the lines merging into each other in a very pretty manner. The additional beam—the latter now having the wholesome proportion of one-seventh of the length—gives, in fact, the naval architect a fair chance of displaying his skill in design, and the question of speed is not so exclusively one of hard driving. The metacentric height is, we understand, about 1 ft. Forward there is a turtle deck, the after part of which is raised into a rectangular conning tower, extending right across the deck. The boat is propelled by one two-bladed screw. The deadwood aft is cut away and the rudder is of the balanced type, the description of stern being that adopted by Messrs. Yarrow & Co. in their most recent first-class, a mode of construction designed by the firm, in 1881, for some boats built for the Chilian Government. The hull of the vessel now under notice is of course of steel, and has fore-and-aft butt straps outside, so as to give a better countersink to the rivets.

The boiler is, generally, of the type used by Messrs. Yarrow for vessels of this class, and contains the distinguishing characteristics of the firm's design. It has copper fire-box and taper tubes; an arrangement which allows additional water space near the furnace tube plate, where the evaporation is naturally most rapid. The engines are of the three-crank triple compound type, with piston valves to all cylinders. They are, in fact, duplicates of the firm's first-class boat engines, excepting, of course, that they are on a smaller scale. The air and feed pumps are worked by a crank on the fore end of the crank-shaft.

There are the usual fan engine and centrifugal pumping engine for supplying cooling water to the condenser. The latter, however, is mainly supplied with water for condensation by means of a natural circulation, set up by the passage of the boat through the water. When the boat is at rest or going astern the centrifugal pump is brought into play. Under the turtle-back and conning tower forward there is a cabin extending up to the collision bulkhead. This will afford accommodation for 12 to 14 men. The hand steering gear is placed in the conning tower, there being no steam steering gear in this vessel, the ease with which she turns, owing to the improved shape, enabling this extra complication to be avoided. Abaft the machinery space there is a good cabin intended for officers, but which will accommodate 12 men if necessary. It has side lights, there being no raised structure for skylights, as the deck above has to be flush in order that the torpedo gun may be worked. Right in the stern there is a good room for stores and gear.

The armament will consist mainly of a torpedo gun placed on deck, and which will swivel on the engine-room after bulkhead. In this way a very wide angle of ejection for the fish torpedo will be obtained on both sides, without moving the boat. It is considered that the firing of a torpedo in this way is more effective than the simple end-on fire of the built-in bow torpedo tubes. These can only be directed by manœuvring the boat itself, which must of course be brought bow-on with the enemy. In such firing the boat has to be very much slowed down, and it is very difficult, or in rough water impossible, to point a boat with accuracy if her speed be too much checked. Of course these conditions as to difficulty in pointing do not apply with the swivel-gun arrangement, for the enemy has only to be brought on anything approaching a broadside, and the weapon can be easily directed. Moreover, it is said that a very fair approximation to accuracy of aim with a Whitehead torpedo can be attained when these boats are running at a high rate of speed. Of course there must be considerable disturbance due to the lateral motion imparted to the torpedo through being carried by the boat, but it is found that with a little practice this can be allowed for, and at short ranges there is small chance that the weapon will not hit the ship. In any case, however, the broadside ejection possesses great advantages, as it gives the torpedo boat a chance of striking her blow with less necessity for diverging from the straight line of approach and retreat. But to manœuvre a 15-ft. torpedo gun carried on the deck of a second-class boat requires more stability than those craft have hitherto possessed, and here it is that the extra width given to this boat has enabled a very considerable advance to be made in torpedo boat practice, a step which probably will do much to re-establish the second class in the good opinion of naval tacticians. From a peace-time point of view the advantages are still greater, for such a craft as Messrs. Yarrow have constructed will be available for the ordinary steamboat work of a man-of-war, more especially as the weight has not been increased in spite of the increased beam and speed; the lifting weight being 11¼ tons. There is a 1-in. Nordenfelt gun forward, and the boat is so arranged that a larger machine gun can, if necessary, be readily substituted for the torpedo gun.

Turning to the performance of the boat, the official trial made the week before last gave the following figures.

The trial consisted of a full-speed continuous run of four hours' duration, the load carried being four tons. The result obtained was a mean speed slightly exceeding 17 knots. During the trial the measured mile at Long Reach was passed over six times, with the following results:

Mile.	Time. Min.	Sec.	Mean Speed.
1	4	3	14.815
2	3	9	19.048
3	4	1	14.938
4	3	7	19.251
5	4	3	14 815
6	3	6	19.355

The above runs were made exactly in the middle of the four hours, and as steam was kept steadily throughout the entire trial, the mean of these six runs was accepted by the authorities as the true speed. The steam pressure was 160 lbs.; the revolutions, 520; the indicated H.P., 225. Each of the three cylinders gave within 8 per cent. of the same power. Circles were turned to port and to starboard, with a view to ascertaining the manœuvring powers of the boat. The diameters of these circles were 135 ft. and 165 ft., the times being 40 and 49 seconds respectively; there was very little heel.

In considering these figures, it is fair to remember the new conditions under which this boat has been tried. In the first place, she is 3 ft. shorter and 1½ ft. wider than the majority of the second-class boats. The trial weights have also been raised from 2½ to 4 tons, an increase of 60 per cent. The duration of the trial has also been extended from two to four hours, a very material point. It is claimed that the extra 1½ tons in load represent one knot in speed, and the additional two hours of trial at least something above half a knot. The average speed of the earlier second-class boats was 16½ knots, so that in No. 50 the Admiralty has acquired a boat about two knots faster, to say nothing of the higher seaworthy and fighting qualities due to increased beam.

It is interesting to compare this little vessel with her forerunners of 10 years ago. In 1878 the speed of the second-class torpedo boat was 15¼ knots—this, if our memory serves us, was the top record—with two tons on board; now we get over 17 knots with four tons of stores, gear, etc. Then the trial extended over a distance of 6 knots only; No. 50 covered above 11 times that distance on her official trial. In 1878 torpedoes were ejected from cradles which had to be lowered into the water alongside, to effect which operation the boat had to be brought to a stand-still. Having then hardly any movement through the water, she would have next to no steerage-way; practically, therefore, no aim could be taken except in the smoothest water, and even then the torpedo could only be directed in a line parallel to the keel. In fact, the whole business was little better than a farce from the point of view of actual warfare. Now the weapon can be ejected by a single movement of the officer in charge, through a range of angle embracing the greater part of the horizon, while the training is done from below. The increased manœuvring powers due to the improved form of stern are also an important factor in estimating the relative value of the types of the two periods. Another point that may be mentioned is the absence of vibration, a feature very characteristic of No. 50.

It is satisfactory to think that this improved boat has been built for our own Navy, and we congratulate the Admiralty officials upon their foresight and perseverance.

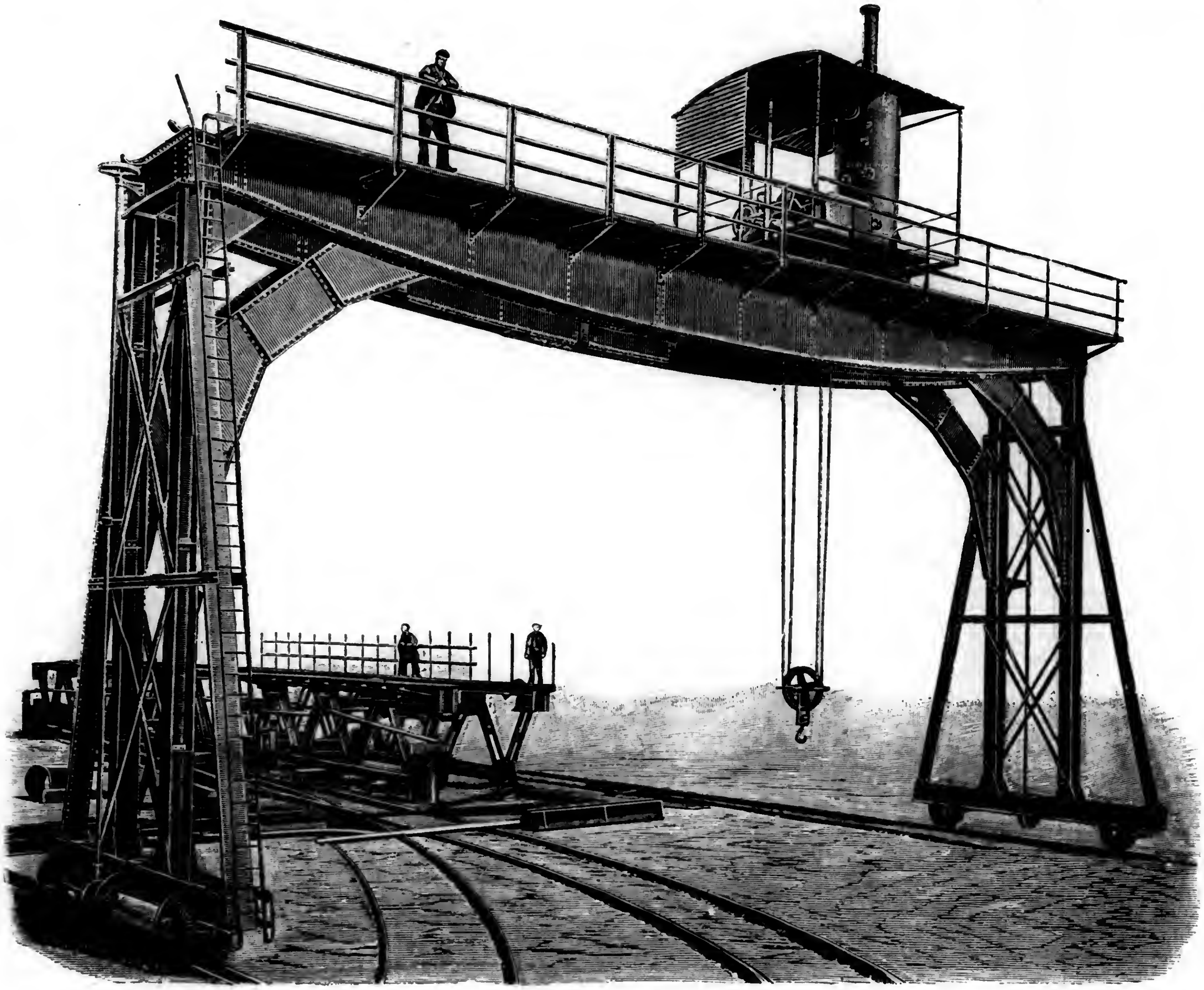
Twelve-ton Steam Traveling Crane.

THE accompanying illustrations (from the London *Engineering*) show a 12-ton steam crane of the "Goliath" pattern, in use at the works of the Darlington Wagon & Engineering Company, Limited, at Darlington, England. The iron work of the crane was made by that company, the engines by Job Isles, of Leeds.

The crane has a span of 60 ft. from center to center of the main rails, and a clear height of 28 ft. from the head of the main rail to the lowest portion of the fish-bellied girders. It is driven with a pair of diagonal engines, having cylinders 6½ in. in diameter by 10-in. stroke, with reversing link motion, and a solid disk crank. The boiler is made of B B Staffordshire plates ⅜ in. thick. It is 8 ft. high and 3 ft. 6 in. in diameter inside, and has a circular internal furnace with three cross-tubes. It was tested to 150 lbs. pressure with water.

The crab consists of strong iron frames and runs on cast-iron double-flanged wheels. One pair of wheels is driven from the engine by a double friction clutch worked by a hand-wheel and screw from the engine platform. The crab can be racked across at the rate of about 40 ft. per minute, with the full load hanging on the crane and the engines running about 120 revolutions per minute.

The hoisting gear is of single and double purchase. The fast speed of lifting is about 18 ft. per minute, and



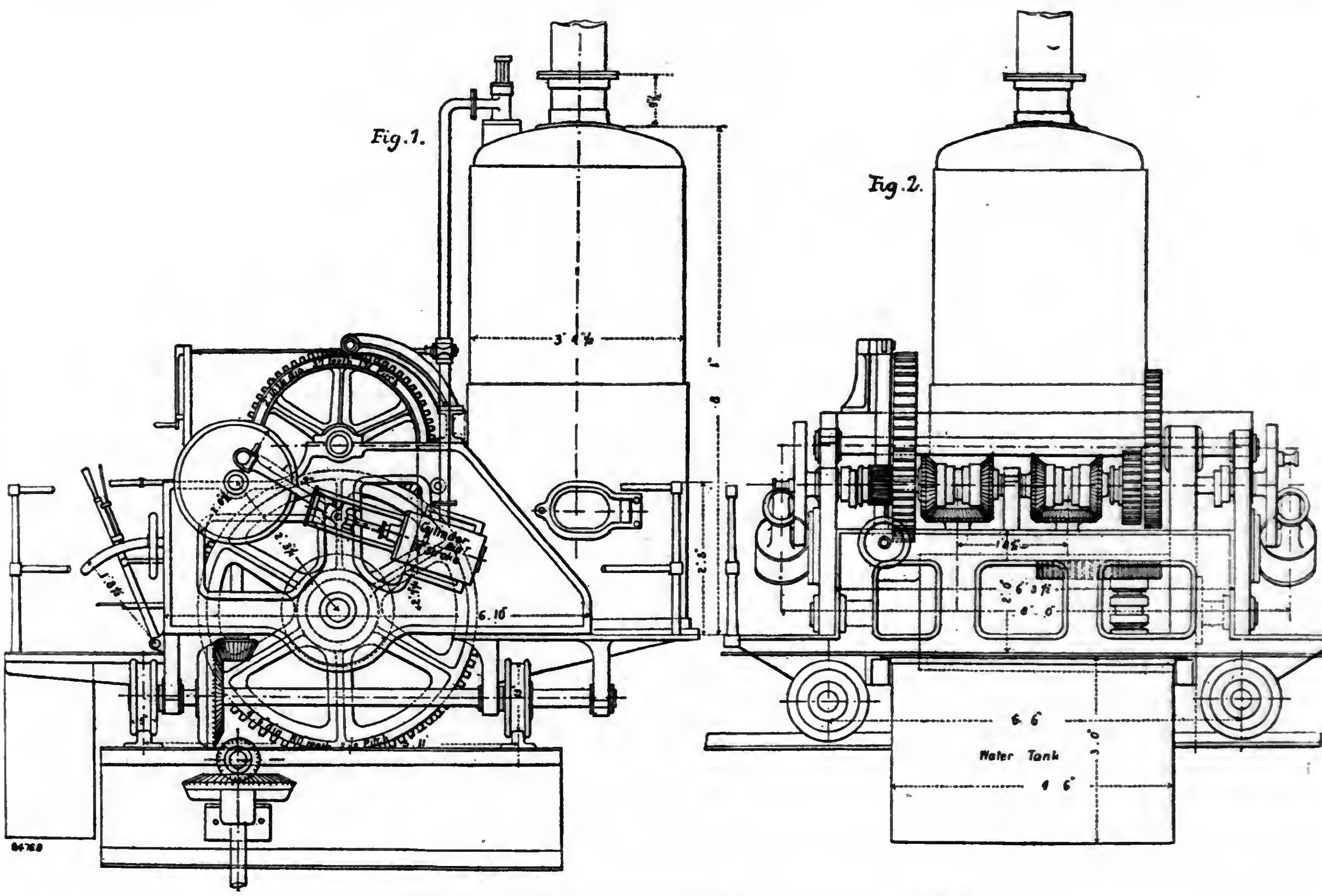
TWELVE-TON STEAM "GOLIATH" CRANE AT THE DARLINGTON ENGINEERING WORKS, DARLINGTON, ENGLAND.

the slow speed with the full load on not less than 10 ft. per minute, with the engines running about 120 revolutions per minute. The main barrel has double right and left-hand steel ropes, so as always to lift square. It is turned all over where the ropes run. The pulleys are all turned where the ropes run, and have steel pins. The barrel lies parallel to the main girders, and its position is so arranged that half the weight comes on each main girder.

The whole crane is driven along the main road by engine power. There are two speeds for this traveling. With the engines running at 120 revolutions per minute, the light crane travels 60 ft. per minute, and the crane with the full load on 40 ft. per minute. This motion is derived from a double friction clutch worked by a hand-wheel and screw convenient to the engine platform. The cross gantry shaft is of steel, and runs in self-acting tumblers. The vertical shaft is of steel also. There are four main traveling wheels, all driven from the engine. The vertical shafts and all their bevel wheels are outside the framework, so as not to reduce the clear span of the crane. The main wheels have steel tires bored and shrunk on, but not turned on the tread.

The ordinary working load is 12 tons, but the crane was tested with 15 tons in the center, and bore this load satisfactorily.

The larger engraving is a general view of the crane. The other cuts are a side view and an end view of the engine and boiler.



ENGINE FOR TWELVE-TON STEAM "GOLIATH" CRANE.

Pumping by Electricity in Coal Mines.

(From the London *Electrical Review*.)

THE electrical pumping plant hereafter described was built by Immisch & Co., of Kentish Town, London, and erected under their superintendence ; the steam power, the pumps, and the piping being supplied by the colliery owners. The particulars and a test of the plant are to be found in the table appended, and will serve to show that, even with ordinary steam-engines and pumps not designed for use with electric plant, the commercial return of useful work is very high. Indeed, the efficiency of electrical plant is as much as 66 per cent. in favorable cases. And, since the efficiency falls off very slowly with the increase of distance through which the power has to be transmitted, this method of driving pumps should find favor in mining circles.

Where steam can be used direct, or be easily carried by lagged pipes, and in most cases where the power can be transmitted by a system of ropes, the electrical engineer will not enter the lists. Electricity really competes with compressed air and hydraulic plants.

Comparisons which have been made show the following results :

Compressed Air Plant.—Pneumatic plant entails a large initial outlay, gives considerable trouble while running, from heating at the compressors and freezing at the exhaust ports. The running expenses are also very heavy. The losses in transmission through horizontal pipes for long distances are also considerable. Against these must be set off the fact, that there is a slight increase of pressure when vertical pipes are used for any part of the way, and that the exhausting of fresh cold air is, near the "faces" at any rate, a great boon.

Hydraulic Plant.—Water under pressure is in many cases a very cheap and convenient way of transmitting power, and if there be a sufficient head to do away with the need of a pumping engine and accumulator on the surface, there is much to be said in its favor.

In most cases, however, an engine and accumulator will be required on the surface, and heavy costly piping has to be laid down. The chief drawback is that water has to be taken down the mine to raise water already there. Cases are known where a gallon of water at high pressure was used for every two gallons raised.

The plant is costly, and, if working at high pressure, gives continual trouble by blowing of joints, etc. The cost of maintenance is thus sometimes considerable.

Electrical Plant.—The requirements for this are a

steam-engine and boiler, a dynamo, motor, and connecting copper cables.

The engine and boiler may be taken as common to all the systems, and the cables are comparable with the piping used in the other systems. The cable is, however, less per foot run than either cast or wrought-iron piping to transmit the same energy, and the cost of erection is far less since there is no jointing to be done. The cable is cleated to the cross timbers on the roofs in a simple and cheap manner.

We have now only the dynamo and motor to compare with the compressors, accumulators, and air-engine of the pneumatic system, or the accumulators and engine of the hydraulic. It will be found that the air compressors, accumulators, and air-engine cost about as much as the dynamo and motor for a similar output. The hydraulic accumulators and engines will cost less than the dynamo and motor, but the want of efficiency and other drawbacks mentioned more than counterbalance this apparent gain in prime cost.

Briefly, then, an electrical system has about the same initial cost as a pneumatic one, and the hydraulic is cheaper than either.

The cost of maintenance of the electric system is, however, far less than either, but exact comparison cannot yet be made, owing to want of data. The dynamo and motor have only the journals, bushes, commutator, and brushes as wearing parts, and even allowing the highest rate of maintenance ever experienced in these machines, the cost will not exceed 5 per cent. per annum of the prime cost.

The high efficiency of electrical plant for transmitting power over long distances also enables a smaller boiler and engine to be laid down; and thus there is a further saving in initial outlay.

A single cylinder horizontal engine was used. The bore was 14 in. and the stroke 15 in. The steam pressure was varied by a reducing valve according to the work required.

This engine was an old girder engine. During the test it was found that the slide-valve nuts had shifted on the bottom end. The diagrams are thus defective, since the steam was admitted too late and cut off too soon on the bottom end. This must have lowered the efficiency of the engine to some extent, and, of course, is against the net efficiency of the system. The power required to overcome the friction of the engine and dynamo without any load was 1.715 H.P.

The motor ran at a speed of about 650 revolutions per minute during the test, the pumps making 8 revolutions.

The gearing consisted of three transmissions. The first a 10-in. cotton belt, the second a mortised pinion gearing into a cast-iron wheel, and the third a cast-iron pinion and a wheel on the crank shaft of the pumps. This complex system for reducing the speed of the motor was, of course, not originally designed so, but circumstances made it convenient to use gearing in this manner.

The pumps were made by Messrs. Bradley & Co., of Wakefield, to the design of Mr. Brown, the engineer at the colliery. They consisted of two separate differential pumps. Each had one 6-in. ram, and one 4½-in. ram. They were coupled by cross heads and connecting rods to the main shafts with the cranks at right angles.

The suction was only made by the 6-in. rams, but all the rams delivered water into the column; there were thus two sections and four deliveries per revolution of the crank shaft, the pump being equivalent to a four-throw pump with 4½-in. rams.

The division of the work done by the large rams was not by any means equal. Though to casual inspection the work done throughout a revolution was constant, an ammeter in circuit with the motor showed considerable fluctuations of current at regular periods. The difference of load thus experienced was as much as 25 per cent., and caused at first some trouble by heating the armature and pole-pieces, if the average current exceeded 50 ampères.

This difficulty, however, was successfully overcome. The same plant was tested under different circumstances about three weeks before these tests were made, and the conversion was then 42 per cent. with a delivery of about 42 gallons per minute through 850 ft. The rise of efficiency to 44.4 per cent. is probably due to the friction of the bearing surfaces being lessened by wear and by the shortened length of piping. But more so by the introduction of the belt transmission which protected the motor from the vibration, which is inseparable from high-pressure pumping plant.

We may mention that this plant is giving great satisfaction, and that the colliery owners, Messrs. Locke & Co., have given the makers, Messrs. Immisch & Co., an order for another dynamo and motor to deliver 120 gallons per minute, through a head of 900 ft. The plant is already in hand, and will shortly be delivered.

PUMPING PLANT AT ST. JOHN'S COLLIERY, NORMANTON.

Pumps delivering 39 gallons per minute through a head of 530 feet = 6.3 H.P. in the water.

Work Done.	Speed of Engine.	Volts on Dynamo.	Average amps. given out by Dynamo.	E.H.P. given out by Dynamo.	Work done in Cylinder of Engine.	Efficiency per cent.	Loss in Cables res. 29 ohms 800 yards 19/16.
Pumps delivering 39 gallons per minute.	86	171 173.5	47.5 47.5	10.9 11	14.2 H.P.	44 4	.88 H.P.
Pumps running with the suction clack lids off and the column empty.	86	134 128 127	28 28 26	5 4.82 4.45	6.3 H.P.	..	.305 H.P. .305 H.P. .265 H.P.
Motor and first motion shaft only.	88 86	111 105	20 20	2 96 2 8	4.8 H.P.	..	.156 H.P.
Dynamo only, running on open circuit.	86	0	0	0	1.715 H.P.	..	0

UNITED STATES NAVAL PROGRESS.

REPORTS recently made to the Navy Department indicate the progress made so far in the work on the new war-ships.

THE NEW SHIPS.

At Cramps' Sons, Philadelphia, the gunboat *Yorktown* is about ready for launching, and the dynamite gunboat will be ready in March. The boilers for the *Yorktown* are finished and the engines are well advanced. The cruiser *Baltimore* has about all of her frames up and plated. The decks are laid, and if material is forwarded from the iron mills it is probable that this vessel will be launched some time in April.

The *Newark* and the *Philadelphia* are making slow progress, the lack of material acting as a bar to rapid work. Material, however, for both of these ships is being received, and the work of construction will go on more freely as soon as some indispensable preliminaries are settled.

From Chester, Constructor Steele reports that work on the *Bennington* and the *Concord* is progressing favorably, but not as rapidly as could be desired. They are, by contract, to be completed by May, 1889, but it is thought that neither of them will be ready for the water at that date. The keels of both these gunboats will be laid by March 10.

The gunboat *Petrel*, under construction at Baltimore, is progressing slowly. This vessel was to have been practically completed by December 22, but it will be some time before the Government will be able to take any steps toward fitting her for sea. The Columbian Iron Works, contractors for this vessel, have made a formal application to the Secretary to be relieved from the penalties for failure to complete her within the contract time.

From New York, Assistant Constructor Hanscom reports that the preliminary work on the armored cruiser to be built at that navy-yard is in a fair state of forwardness. Her lines have already been laid off in the mould loft, and the blocks and platforms are in place for building the ship. Tools and general plant, as well as material, have already been contracted for, and as soon as the machine shop and store-house are completed, the various details will begin to assume shape. It is not probable, however, that much will be done in the way of actual construction before July or August next. The preliminary steps for the two gunboats to be constructed at New York are still in embryo, but the spring will probably see rapid progress in their

erection. The *Chicago*, having undergone a most successful power trial, is waiting for orders from Washington to be fully completed and fitted for sea. The *Boston* is practically completed, but has only a portion of her battery on board. It will, it is said, require additional appropriation to complete the ship, armed and equipped ready for sea. The *Boston* and the *Atlanta* are in commission, and the latter craft will probably sail for the West Indies as soon as the work found necessary on her bottom shall have been completed.

The armed cruiser in process of building at Norfolk Navy-yard, Va., is in pretty much the same condition as the similar vessel at the New York yard. Progress on both of these huge vessels will be necessarily slow.

These two ships, to be built at the New York and the Norfolk yards, will be the largest vessels in the Navy. They will be named the *Maine* and the *Texas*.

The *Charleston*, at San Francisco, is progressing very favorably, and were it not for the unexpected delay in the shipment of material from the East, the contractors for this vessel would be well abreast of the terms of the contract. As it is, the *Charleston* will be among the new ships to be finished long after the date specified in the contract.

The *San Francisco* is still in the future, as far as actual work is concerned, and it will be many months before she is launched.

From all the contractors the complaint comes that material is not supplied fast enough by the rolling mills.

THE PITTSBURGH CAST-STEEL GUN.

The accompanying sketch, from the *American Manufacturer*, shows the gun recently cast at the works of the Pittsburgh Steel Casting Company in Pittsburgh. The plain lines show the finished size of the gun; the dotted lines show the size of the casting, the portion above the breech being the sinking-head for feeding the shrinkage of the casting. The gun was cast in a vertical position, the muzzle end downward.

The total length of the casting over all was $276\frac{3}{4}$ in. The sinking-head, which was made in two diameters, is 72 in. long. The part immediately above the gun, which was 48 in. long, is $16\frac{1}{2}$ in. in diameter at the top, and 17 in. at the breech, the smaller section, which is 2 ft. high, being 15 in. in diameter at the bottom and $14\frac{1}{2}$ at the top. The finished length of the gun is 193.53 in.; the total weight of the metal, 18,490 lbs.; the length of the pattern for the gun proper, $204\frac{3}{4}$ in.

The mould, as stated above, stood on its end, in a pit dug for the purpose, its top rising about 6 ft. above the ground.

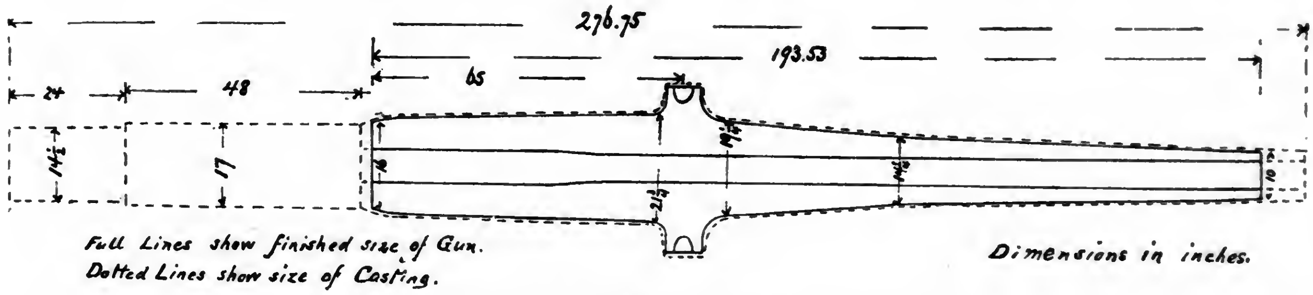
The casting, as well as the entire arrangements for the same, were under the personal direction of Mr. William Hainsworth, the General Superintendent of the works.

After being allowed to remain in the mould five days to cool, the gun was removed and carefully and thoroughly examined without showing the least flaw. It has since been put in the lathe and turned, on the outside, the small amount of reduction that is called for, still without developing any flaws, and the rough boring has begun. As soon as this is finished it will be shipped to the Navy-Yard at Washington, where it will be machine-finished, which must be done within four months after delivery by the contractor, while the statutory test of the gun must take place within three months after the completion of the machine finishing. This test is to consist of 10 rounds (the weight of the projectile and muzzle velocity being at least 100 lbs. and 2,000 foot-seconds respectively) fired as rapidly as the gun can be loaded by hand and discharged. The gun will be critically inspected after this test and the piece must not exhibit any defects or weakness.

Samples of the steel have been subjected to the following physical tests, which shows it to possess to a remarkable degree the qualities which theoretically are best adapted to withstand the strains which it will be called upon to endure. One of the test pieces taken from near the trunnion, and unforged, was given the usual tests for tensile strength, elastic limit and elongation, with results as follows: Ultimate strength, 92,700 lbs.; elastic limit, 51,960 lbs.; elongation in 2 in., $12\frac{1}{2}$ per cent. Samples taken during casting, under cold bending tests, gave the following results: Pieces forged from 2-in. square ingot to $\frac{5}{8}$-in. square, and allowed to cool, were bent cold to an angle of 161° without fracture. The other tests have been made from steel cut from the gate or runner, which was at one side of the gun. The runner, which was originally $2\frac{3}{4}$ in. in diameter, was turned down to $2\frac{9}{16}$ in., and cut into pieces $4\frac{1}{2}$ in. long. These pieces were then drilled or bored out through the longitudinal axis with a $1\frac{1}{8}$-in. drill. This size was adopted because the ratio of the diameter of the hole through the center to the outside diameter is the same as the ratio of the bore of the gun to its outside diameter at the thickest part of the breech. A round conical wedge, $1\frac{9}{16}$ in. long, the ratio of its diameter to its length being 1.125 : 14.250, was driven into the $1\frac{1}{8}$-in. hole in these test pieces by blows from a steam-hammer, the weight of the hammer being 1,000 lbs., and the area of steam cylinder $122\frac{3}{4}$ in., steam pressure about 75 lbs., drop of the hammer 1 ft., giving about 10,000 foot-pounds at each blow. This wedge was driven in flush at the fourth blow. It was then forced out by means of an Olsen testing machine, requiring a force of 28,450 lbs. The test piece was not ruptured.

Another test of a different character, designed to show the great stiffness of this steel as compared with forged steel (39 carbon), was made. A piece of the runner $2\frac{3}{4}$ in. diameter and about 14 in. long, supported by small pieces of steel $\frac{5}{8}$ in. square placed 12 in. apart on an anvil, was struck 21 blows with a 35-lb. sledge, without result. It was then placed under the steam hammer and given 18 blows, which caused it to deflect $\frac{1}{4}$ in., the last blow breaking it in two pieces.

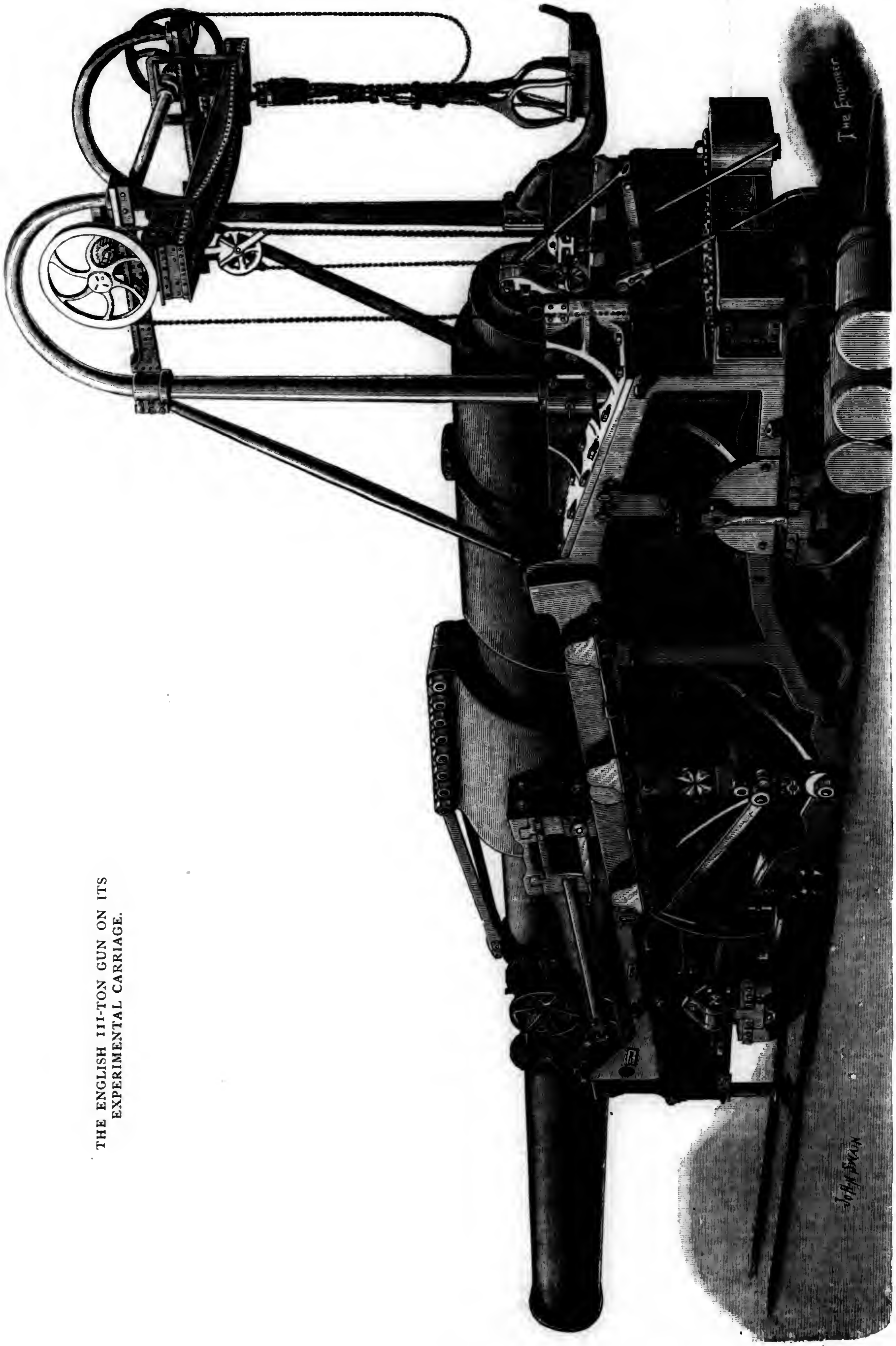
The comparison of this cast gun with the built-up steel guns may develop some interesting points.



STEEL GUN CAST FOR THE NAVY BY THE PITTSBURGH STEEL CASTING CO.

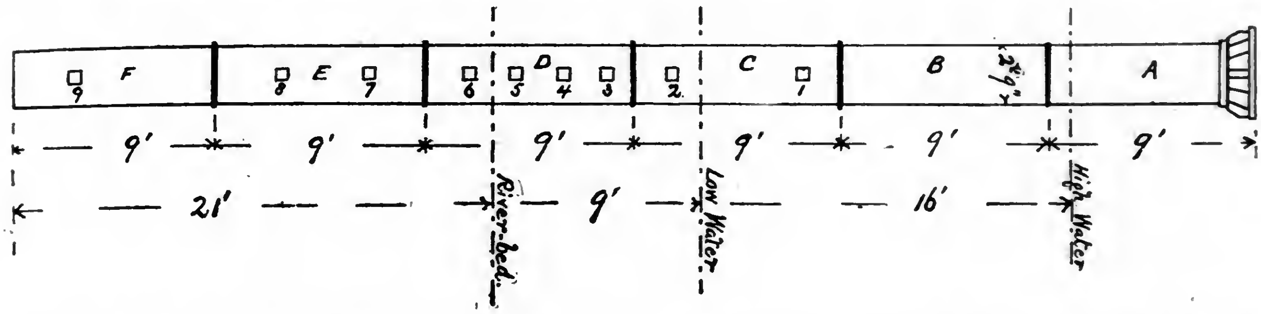
Action of Salt Water on Cast-Iron Piles.

SOME interesting experiments are reported by the *Indian Engineer*, which were recently made to test the condition of cast iron after a long period of exposure to salt water. These experiments were made by Mr. Hargrave, Resident Engineer of the Bombay, Baroda & Central India Railroad, and the special object was to ascertain whether there was any danger affecting the foundations of a number of bridges on the road, which rested upon piers formed by



THE ENGLISH 111-TON GUN ON ITS EXPERIMENTAL CARRIAGE.

clusters of cast-iron columns. The particular column chosen for the experiment was one taken from pier No. 37 of the bridge at South Bassein, which spans a tidal estuary where the water is sea or salt water. This was one of the original columns, put in position in 1862, so that its age at the time of the test was 25 years. This column, as shown in the accompanying sketch, was made of joints 9 ft. in length, bolted together at the flanges. For convenience of reference each joint of the pile in the diagram is



lettered and the test pieces which were cut out are numbered.

Specimens 9, cut from joint *F*, 8 and 7 from joint *E*, both of which were entirely below the river-bed, showed no corrosion whatever. Of those cut from joint *D*, which was partly in and partly above the river-bed, specimen 6 showed no corrosion; while Nos. 5, 4, and 3 were slightly corroded, but the greatest depth of this corrosion measured did not exceed $\frac{3}{32}$ in. This greatest corrosion was shown in No. 3, which is near the low-water mark, and about the same amount was shown in No. 2 in joint *C*, which was also near the low-water mark. The upper joints *B* and *A*, which were under water only at high tide, and thus were part of the time exposed to the action of the salt water and part of the time to the air, showed no corrosion whatever.

As to the bolts by which the joints of the pier were held together, the inside bolts were in good condition, while the bolts on the outside showed so little action from the water that they might be considered as good as when put in.

Engineer Hargrave says, in concluding his report:

"The lesson to be learned from this experiment is that the greatest corrosion in the piles exists close to low-water and does not extend to any considerable depth underneath it; the same has been observed in the case of the bolts and bracings. If this column can be taken as representing the average condition of the remainder of the columns in this bridge, we are in a position to state that, after a period of 25 years, our pile columns in a salt waterway are in a very good condition, and that the piles, where corrosion has been found, are in a position which can be easily got at for examination or renewal. This experiment further sets at rest all groundless fears as to the speedy deterioration of our pile columns from the action of sea water. The specimens have been put up in a neat case, which should be kept for future reference—when possibly 25 years hence another column may be examined and the results compared."

THE ENGLISH 111-TON GUN.

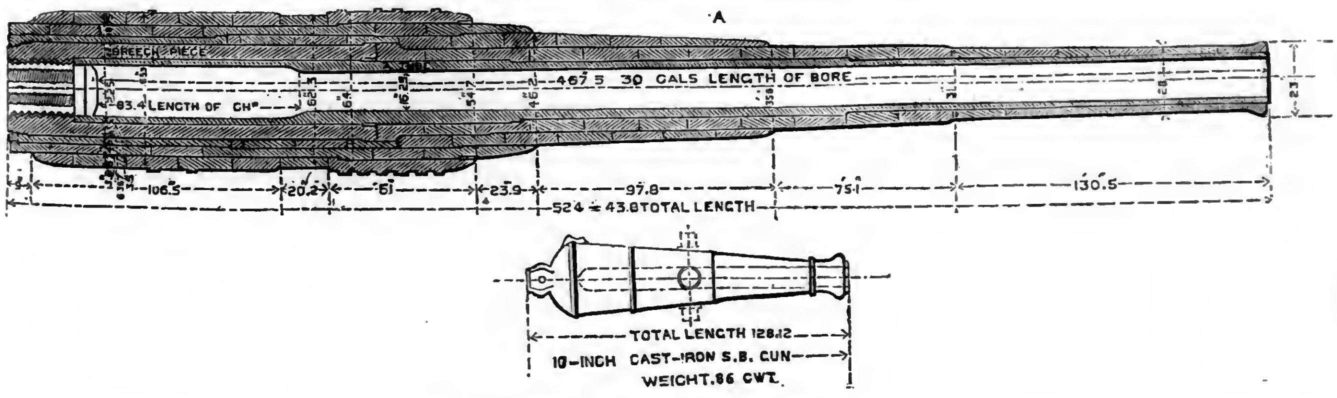
(From the London *Engineer*.)

Now that the *Benbow* is approaching completion in every respect, and about to be brought round from Chatham to Portsmouth for a trial of her great 111-ton guns, it is not an inappropriate time to say a few words in regard to the power and value of her armament, far surpassing—as it does—that of any ironclad afloat, whether in the navy of Great Britain or in that of any foreign power. The accompanying table will show in a moment that the 111-ton gun distances all competitors. In it a comparison is drawn between the salient features of our new weapon and those of the heaviest natures possessed by France and Italy, these being the only rivals worthy to be compared with it:

Country.	Caliber. Ins.	Weight. Tons.	Muzzle-velocity. Foot-secs.	Projectile. Lbs.	Penetrative Power.
Great Britain..	16.25	111	2,128	1,800	32.5 in. at 1,000 yds.
Italy	17	104	2,018	1,799	32.3 in. at muzzle.
France	14.66	71	1,955	1,180	27.3 in. at muzzle.

Thus it will be observed that the *Benbow's* gun has a greater penetrative power at 1,000 yards' distance from the muzzle than the Italian gun, its most formidable competitor, has at the muzzle itself. This would appear to be conclusive.

Before giving a brief description of the construction and parts of the new gun—drawings of which we give—we



ENGLISH NAVAL GUNS—1887 AND 1857.

cannot refrain from remarking upon the prodigious strides which have been made in the development of gunnery science since the period of our last great war, both as regards the dimensions of the weapons employed and the complex nature of the machinery by which they are loaded and fired. A glance at the sketches given herewith, which give the relative sizes of the modern 111-ton steel rifled breech-loading gun and the old 10-in. cast-iron smooth-bore gun of a past age—drawn to the same scale—will exhibit at once the extraordinary rapidity of that development as far as regards proportions. It must be borne in mind that at the close of the Crimean War—only 30 years ago—the 10-in. smooth-bore gun was the heaviest and most powerful piece of ordnance that Great Britain possessed,

and we were then far ahead of all other nations in respect of armament. Yet in the present day the projectile and battering charge only of our most formidable weapon, taken collectively, actually bear an appreciable proportion to the entire bulk of the gun, which was considered monstrous in 1857, computing to one-third of it in weight. The complicated nature of the machinery required to load, fire, and control the new gun can be seen by a reference to the large engraving. It shows the gun mounted upon its proof-sleigh at Woolwich Arsenal, and the powerful double derrick erected in rear of it, with traversing platform working beneath the davits for raising and supporting the projectile and charge—weighing respectively 1,800 lbs. and 960 lbs.—during the process of loading; also the duplex arrangement of Stanhope levers, carrier, and cam-lever at the breech, forming quite a bewildering maze of mechanical contrivances. The elevating, loading, and traversing will, of course, be performed by hydraulic power on board the *Benbow*, where the turrets are open and the breech of the gun is depressed beneath the steel deck for receiving its charge; but the mechanism of the breech-loading apparatus is as shown in the engraving.

The principal dimensions of the 111-ton gun are as follows: Total length, including breech gear, etc., about 45 ft.; extreme diameter, 65.5 in.; caliber, 16.25 in.; length of bore, 487.5 in., or about 30 caliber; diameter of powder chamber, 21.25 in.; capacity of same, 28.610 cubic inches; the charge is 960 lbs. of what is called experimental slow powder, of hexagonal shape, with a hole through the center, and almost analogous in its character to the well-known prismatic No. 1 brown, of which most of the charges for many breech-loading guns are now made up. The building up of these charges is most curious. It is like a child's puzzle-map. A plan is drawn of the exact number of hexagons that will most nearly cover a space equal to the base of the charge. Rows and rows are then placed upon the first layer, always leaving the central holes clear above one another for the flash to communicate with the whole mass, as the sides fit exactly. The mass when made up fits into a stout silk bag, and after being "choked" is put into a long metal cylinder for conveyance on board ship; 560 of such cartridges form the "unit" for the *Benbow* in peace time.

An initial velocity of 2,143 foot-seconds was actually obtained on March 28 last at the proof butts, Woolwich Arsenal, with the second of the 111-ton guns. This was with 850 lbs. of German powder only. It is not unreasonable, therefore, to assume that a higher velocity than that mentioned in our comparative statement might be regarded as normal. Of course this greatly increases the penetrative power of the projectile, and the *vis viva* or energy stored up in it. Making use of the generally accepted formula:

$$\textit{vis viva} = \frac{w\,v^2}{2\,g}$$

(where w is weight of projectile in pounds; v velocity in feet, and g = force of gravity, or 32.2—the result being in foot-pounds) we arrive at a muzzle energy with our newly-constructed gun of no less than 57,304 foot-tons, or nearly 5,000 foot-tons in excess of anything before arrived at, the greatest amount of energy before recorded being that of the 100-ton Elswick gun of 17-in. caliber. It is true that higher estimates have been given by various writers of the energy developed by this weapon, but it must be remembered that they were conjectural. Lord Brassey gives it in a table as 61,200 foot-tons. As, however, in order to produce this abnormal energy he quotes a muzzle velocity of 2,214 foot-seconds, which has not been obtained during the Government trials at the Woolwich butts, the figures resulting from these velocities are misleading and untrustworthy. Be it as it may, however, the 111-ton gun stands unrivaled among its compeers, and the *Benbow*, the *Sans Pareil*, and the *Victoria* will have by far the most powerful armament afloat in all the navies of the world. We only regret one circumstance connected with the mounting of these guns; it is that they should be so entirely exposed above the open turrets. This, however, is a defect of the *Admiral* class construction which cannot, we fear, be remedied.

RAILROAD ACCIDENTS IN NEW YORK.

THE report of the New York Railroad Commission for the year ending September 30 last gives a tabular statement of all the accidents to persons, and their causes, reported for the years 1887 and 1886. This table, condensed, gives the total number of casualties as follows:

	1887.		1886.	
	Killed.	Injured.	Killed.	Injured.
Passengers	22	91	30	95
Employés	199	900	159	788
Others	311	269	314	255
Total	532	1,260	503	1,138

The comments of the Board on the statements in this table are given below.

A careful investigation of the causes of death and injury show that the *increase* was not the result of defective construction or rules or discipline, but rather of unpreventable causes or of misconduct or carelessness upon the part of those killed or injured. While during the year ending September 30, 1886, 19 passengers were killed and 52 injured *from causes beyond their own control*, during the last year but 2 were killed and 35 injured from such causes. By their own misconduct or want of caution, however, 16 were killed and 50 injured in 1887, as against 9 killed and 31 injured in 1886. The same is true with regard to employés: 9 were killed and 72 injured from causes beyond their own control in 1887, as against 25 killed and 149 injured in 1886. The increase in the total number of people killed in 1887, as compared with 1886, is due to the fact that 102 employés were killed while walking or being on track in 1887, as against 51 killed the same way in 1886.

The principal cause of death and injury to passengers was getting on or off trains in motion—7 out of a total of 22 killed, and 31 out of a total of 91 injured. This was the fourth cause leading to death to employés, having caused 9 deaths and 28 injuries. Greater care should be observed by both passengers and employés in regard to this matter.

The most serious cause of death to employés, as in 1886, was walking or being on the track, a danger incident to their occupation, and probably not preventable in any way. It resulted in 102 deaths and 88 injuries, as against 51 deaths and 59 injuries in 1886. The next cause of death and injury was falling from trains, engines, or cars, resulting in 37 deaths and 99 injuries in 1887, as against 30 deaths and 93 injuries in 1886. In addition to the employés thus killed, there were 3 others killed and 9 injured, being trespassers engaged in stealing rides. The Board, in its last three annual reports, has called attention to the great danger that trainmen are subject to in setting the brakes on the roofs of freight cars, particularly in frosty weather when the running boards are slippery, and a brakeman is liable to be thrown to the ground by any sudden jerk, or stoppage, or curve in the track. It has recommended to railroads the adoption of a low railing around the roofs of the cars to prevent this. The recommendation, however, has been disregarded by the railroads heretofore, and this year the Board submits to the Legislature a draft of a bill to compel the adoption of such railings, to which your attention is especially directed. Should a continuous air-brake be adopted by railroads generally, it will do much to diminish this cause of mortality to employés.

The cause leading to the third greatest number of deaths, and to injuries equal in number to all other causes, was coupling or uncoupling cars. This resulted in 20 deaths and 437 injuries, as against 23 deaths and 365 injuries in 1886. It is to be hoped that the general adoption of the automatic coupler hereafter alluded to will, before long, materially diminish this serious cause of death and injury.

The most serious cause of death to others not employés or passengers was walking or being on the track, having caused the death of 233 and injury of 124, as against the death of 247 and injury to 111 in 1886.

The next cause of death to others was being run over at highway crossings. This resulted in the death of 42 and injury to 57, as against the death of 28 and injury to 43 in 1886. Of the killed, 12 were at crossings protected with gates or flagmen, and 9 injured at such crossings. This subject is further discussed under the head of legislation.

While a great improvement has been accomplished within the last four or five years in the maintenance and construction of railroads, in the adoption of uniform rules and signals, in the improvement in the construction of bridges, much yet remains to be done to still further diminish the dangers of railroad travel. To this subject the Board gives its most careful consideration.

ACCIDENTS ON MASSACHUSETTS RAILROADS.

(From the Report of the Massachusetts Railroad Commission.)

THE record of accidents for the year ending September 30, 1887, is even more lamentable than that of the preceding year, though that far exceeded the average in the number of casualties. Ten collisions and 8 derailments caused the death of 28 persons and injured nearly 200. These accidents were investigated by the Board.

The whole number of persons injured (as reported to the Board at the time the accidents occurred) was 802, an increase of 211 over last year, due in a great measure to the Bussey Bridge disaster. Of these, 198 were passengers, 357 were employés, 54 were travelers at highway crossings and persons lawfully at stations, and 193 were trespassers, who were unlawfully on the track or stealing rides on freight trains. The number of passengers killed or injured was larger than last year by 84, and there were 83 more casualties to employés, an increase of more than 73 per cent. in passengers and 30 per cent. in employés. There were 10 more persons killed or injured at grade crossings and stations, and 34 more trespassers suffered the penalty of their offense.

Of passengers 23 were killed and 121 were injured by causes beyond their own control, while 14 were killed and 40 were injured through their own misconduct or want of caution, a slight decrease in the total casualties of this class from the preceding year. There is a discrepancy in the number of passengers injured in the Bussey Bridge disaster as returned at the time of the accident and the number reported in the annual return of the Boston & Providence Railroad. The number first reported was 100, but by the annual return the number known and claiming to have been injured was more than 200. A large part of this excess is probably made up of indefinite, uncertain, and perhaps imaginary injuries.

Of the casualties to employés, 79 were fatal and 278 were not fatal. Eleven were killed and 111 were injured when coupling or uncoupling freight cars. Eight of these accidents occurred where one of the couplers was an authorized automatic coupler, one where both couplers were authorized automatic couplers of the same kind, and five occurred in coupling passenger cars equipped with the Miller hook to freight cars having the link-and-pin drawbar. Four employés were killed and 6 were injured by contact with overhead bridges or other structures less than 18 ft. above the track; 6 were killed and 26 injured by train accidents; 24 were killed and 50 were injured by falling from trains; and 34 were killed and 85 were injured by accidents from a great variety of causes. Most of them were due to crossing or standing on tracks or incautiously stepping in front of a moving engine or car in railroad yards, or jumping from moving trains.

At grade crossings of highways protected by gates or flagmen there were 17 casualties, and at crossings without gates or flag there were 30; of these 19 were fatal and 28 not fatal. This is a decrease of 3 fatal accidents and an increase of 15 not fatal. Three persons were killed and 4 were injured when imprudently crossing the tracks at stations.

Trespassers, as usual, furnish the largest number of fatal casualties, 126 having been killed, while 67 were injured not fatally. Last year 91 were killed and 68 were injured. Of the trespassers killed, 11 are reported as apparently suicides. Twenty-six were reported as intoxicated at the time of the accident, and it is not improbable that others who were killed while lying on the track were in a like condition.

It appears also from the reports that eight of the passengers killed or injured through their own imprudence were under the influence of liquor.

If all the companies adopted the same rule in reporting accidents, there is a great difference in the number of actual casualties on the several roads in proportion to their traffic. In the case of passengers killed and injured through their own fault there are no sufficient data on which to base a comparison, as we do not know the number of passengers carried in Massachusetts. The following table shows the ratio of passengers injured to the miles operated in Massachusetts; but as some roads carry more passengers than others on the miles operated within the State, the comparison is not accurate.

Railroads.	Miles Operated in Massachusetts.	Passengers Injured by their Own Fault.	Ratio.
Boston & Albany	332	7	1 to 47 miles.
Boston & Lowell	191	5	1 to 38 "
Boston & Maine	262	16	1 to 17 "
Boston & Providence	57	2	1 to 28 "
Fitchburg	227	12	1 to 19 "
New York & New England	109	1	1 to 109 "
Old Colony	460	7	1 to 65 "
Four Southern Roads	958	17	1 to 56+ miles.
Three Northern Roads	680	33	1 to 20+ "

The Old Colony Railroad, being almost wholly within the State, affords the fairest ratio of passengers injured to miles operated. It will be seen that the proportion of such accidents to miles operated is much less on the four roads entering the city of Boston on the south side than on those entering on the north side.

This is also true in comparing these casualties with the total number of passengers carried—being 1 to 1,920,881 on the south-side roads, and 1 to 933,002 on the north-side roads. The ratio would be still more favorable to the south-side roads on the basis of total passengers carried within the State on the several roads. The question arises whether the passengers on the south-side roads are more careful than those on the north-side roads, or are better guarded from the results of their own imprudence—or if the accidents are as fully reported.

There is a similar difference in the reported accidents to employés, and it is evident that the several roads do not adopt the same rule as to what casualties shall be reported. While some report slight injuries both to passengers and employés, others report only those which are fatal or very serious. The Boston & Albany and the Fitchburg report many accidents to employés while coupling or uncoupling cars, while the Boston & Providence reports no accidents of that kind, and the Old Colony but three. Many of the injuries reported by the former roads are comparatively slight, and it does not seem probable that the employés of the Boston & Providence and the Old Colony escape the minor accidents of bruised thumbs and broken fingers which occur so frequently on the Boston & Albany and the Fitchburg roads.

The following table shows the proportion of employés killed and injured to the whole number on the several roads terminating in Boston:

Railroads.	Total Number of Employés.	Number Killed and Injured.	Ratio	Per Cent.
Boston & Albany	5,698	96	1 in 59	.017
Boston & Lowell	4,066	41	1 in 98	.010
Boston & Maine	5,017	33	1 in 152	.006
Boston & Providence	1,011	5	1 in 202	.004
Fitchburg	3,324	82	1 in 40	.024
New York & New England	3,189	50	1 in 63	.015
Old Colony	3,517	17	1 in 207	.005

The last railroad year makes an unfortunate comparative showing in accidents to passengers from causes be-

yond their own control. The proportion of killed and injured to the total number of passengers carried was: Killed, 1 in 3,605,363; injured, 1 in 685,317. This is, with one exception, the highest ratio for any year on the last decade, as shown by the following table:

PASSENGERS KILLED AND INJURED FROM CAUSES BEYOND THEIR OWN CONTROL.

YEAR.	Killed.	Injured.
1878	0 in 37,318,427	1 in 18,659,213
1879	1 in 2,246,522	1 in 232,057
1880	1 in 45,151,152	0 in 45,151,152
1881	1 in 12,458,622	1 in 7,119,213
1882	1 in 55,868,694	1 in 18,622,898
1883	0 in 61,530,747	1 in 2,563,781
1884	1 in 3,482,952	1 in 1,160,984
1885	0 in 69,603,700	1 in 5,800,308
1886	1 in 7,584,258	1 in 2,166,931
1887	1 in 3,605,363	1 in 685,317

None of these tables, however, are satisfactory for purposes of comparison, because, while the number of accidents given include only those in Massachusetts, the number of passengers carried includes all carried outside of, as well as within, the State; and the number of employés includes all employed on the whole length of the roads operated by the several companies. . . . . .

It is important that this Board should be notified at once, by telegraph or telephone, of any serious train accident. The examination of the wreck before it has been disturbed renders the investigation into the causes of the accident much less difficult. It is true that the wreck may be burned, and that in many cases, even when notice is given immediately, it will be necessary, before any member of the Board can arrive on the scene, to clear away the wreck for the passage of trains, to replace sleepers, frogs, and rails, and perhaps break up shattered cars so as to get them out of the way, and that important features may thus be lost sight of. It should be made the duty of some official, after attending to the wounded, to make a rough diagram of the wreck, showing the locations of the different parts of it with reference to each other and surrounding objects, such as trees, rocks, telegraph poles, houses, etc.; and also a brief, general description of the condition of its different portions.

Great assistance in investigating the causes and details of the Bussey Bridge disaster was rendered by the numerous photographs which were taken. Amateur photography is now so common, and the process so simple, that it seems not unreasonable to request that railroads, in connection with their wrecking apparatus, should have a photographing outfit, and that they should, when possible, cause photographs to be taken of the wreck from several points of view, so that the exact position of it with reference to surrounding objects, and the condition and position of the cars, bridge or other débris, may be clearly shown. No legislation upon this subject is necessary, as the railroads will undoubtedly comply with the expressed wish of the Board.

Formulæ for the Resistance of Iron and Steel.

(Note by M. Bricka in *Annales des Ponts et Chaussees.*)

THE attention of engineers in France has been for some time called to the experiments of Wöhler and Spangenberg relative to modifications undergone by the resistance of metals when they are submitted to repeated strains.

M. Considère has analyzed these experiments in his paper on the use of iron and steel in construction, published in the *Annales* for April, 1885; M. Sejourné, Engineer of bridges and roads, has made them the subject of a note which is known to many of our associates; M. Flamand has referred to them in his report of the commission on the resistance of steel; M. Mayer has published recently (*Annales* for December, 1886) a very interesting account of the last work of Bauschinger, who continued the work of Wöhler and Spangenberg; finally, we have had occasion in a paper on Metallic Bridges, in the *Annales* for March, 1887, to cite the formulæ of Launhardt and Weyrauch,* which are deduced from the laws of Wöhler, and which are now generally employed in Germany.

These formulæ of Launhardt and Weyrauch were some years ago, I believe in 1881, the subject of a very interesting discussion in the Society of Engineers, in which MM. Tresca, de Comberousse, and other eminent engineers took part. In this discussion some of the speakers brought up the point of how much the experiments of Wöhler and Spangenberg, in which the strains were repeated at extremely small intervals, differed from the conditions realized in actual practice, in relation to different parts of iron structures; and here we should remember that these experiments were made with the view of studying the work of metal in the wheels of cars and not in bridge girders. It was also remarked in this discussion that, at least when the strains were of the same kind, their indefinite repetition was found to be without danger so long as the limit of elasticity is not reached. The engineers who had taken part in this discussion were especially almost unanimous in setting aside the principle which served as the basis of the formulæ of Launhardt and Weyrauch, which makes the coefficients of resistance rest upon the consideration of the limit of the breaking strain.

The discussion of the experiments of Bauschinger shows incontestably the justice of the observations made to the Civil Engineers' Society. These experiments have proved, in fact, that the length of the interval of time between the application of successive strains may be neglected; and that a test piece may be submitted to strains repeated several million times without causing modifications either in its structure or in its resistance to statical strains.

The results found by this experimenter, so far as relates to variations to which the limit of elasticity is subject, under certain conditions, serve, moreover, to confirm the justice of the principle adopted by French engineers, who hold that the stability of the structure is no longer assured when this limit is passed.

To recognize how hazardous the application of the laws of Wöhler to constructions in metal is, it is not necessary, in our opinion, to study experiments made, like those of Bauschinger, with readings to two-thousandth of a millimeter. The variations to which the limit of elasticity is subject under strains which reach this limit were long since known in France from the very simple experiments of M. Tresca. As to the invariability of structure and of resistance to breaking of iron or steel submitted to such strains as those carried by metallic bridges, it is easy to verify that by experiments on the rails of a railroad track. These rails are, from the point of view of the influence of constantly changing strains, placed under the most unfavorable conditions; their weight in the interval comprised between two successive shocks may be absolutely neglected in comparison with the variable loads, which always exceed one ton for the wheels of the cars, and which sometimes reach as high as seven tons for the wheels of the locomotive; the rails receive these shocks directly, without the interposition of any elastic material; frequently the metal is subjected alternately to strains of tension and compression according to the position of the wheels. On the other hand, these strains reach a very high limit under the passage of locomotives.

In the track of the Orleans and of the State Railroad,

* The formula of Launhardt is as follows for iron:

$$R = 800 \left(1 + 1 \frac{S \text{ min.}}{S \text{ max.}}\right)$$

For steel:

$$R = 1200 \left(1 + \frac{9}{5} \frac{S \text{ min.}}{S \text{ max.}}\right)$$

For pieces in which the strain is always in the same direction.

The formula of Weyrauch is as follows for iron:

$$R = 700 \left(1 - \frac{1}{2} \frac{S \text{ min.}}{S \text{ max.}}\right)$$

For steel:

$$R = 1100 \left(1 - \frac{5}{11} \frac{S \text{ min.}}{S \text{ max.}}\right)$$

For pieces in which the direction of the strain varies.

In all these formulæ S min. and S max. indicate in absolute value the smallest and the greatest strains to which the pieces calculated can be subjected.

one of the best which exists in France, the tension and the compression per square millimeter, supposing that all the ties are uniformly tamped, are not less than 8½ kilos. when the rail has not had much wear ;* they increase to 13 kilos. when the two rail-heads have had each a wear of one centimeter. Now, it frequently happens that ties badly supported yield under the pressure of the wheels, and the derangement thus produced by the loss of one of the points of support increases in considerable proportion the work of the metal. Under these conditions, if we take into account the numerous causes of weakness to which rails are subjected up to the moment when their renewal becomes necessary (diminution of the section of the metal in consequence of wear ; play of the chairs ; weakness of the fastenings ; depreciation of the quality and the quantity of the ballast), we are astonished that the number of breakages is not greater, and we can confidently affirm that it would be very much greater if the variation of the strains to which the metal is subjected produced any sensible alternation in its constitution.

It would be easy to assure ourselves that rails do not change, by means of trials made on steel rails which have arrived at the limit of wear of lines of heavy traffic ; we might admit that, up to the time when they are taken out of the track, they have been subjected to the passage of not less than 200,000,000 tons, which, if we assume an average load of five tons per axle, corresponds to the repetition of the strain 40,000,000 times. We have not had at our disposal rails under these conditions, but we have been able, thanks to the kindness of M. Planché, Director of the forges of St. Nazaire, to test some pieces of iron rails which had been for 20 years in the main track of the lines from Saintes to Angouleme, from Nantes to La Roche-sur-Yon, and from Niort to La Poussoniere, and which had supported the passage of about 1,200,000 axles. These tests have given on the four samples a resistance to tension of 31, 35, 37, and 39 kilos. to the square millimeter, and limits of elasticity exceeding 22½ kilos. Now, we can see that at the end of 20 years and after the passage of over 1,200,000 axles, the iron of rails exposed to strains which very often exceed 8 kilos. to the square centimeter is still, from the point of view of resistance, equivalent to metal of the first quality. From this we can certainly conclude that in any structure where the action of accidental strains is exercised under conditions infinitely more favorable it will not produce, even after a very considerable number of repetitions, any injurious effect.

The extension to metallic bridges of the results of the experiments of Wöhler and Spangenberg is, then, in our opinion, condemned as much by the results of the experiments of Bauschinger as by the observation of facts ; nevertheless it does not follow that we should reject purely and simply the formulæ based upon these experiments. If we look only from the point of view of the coefficients of work to which it leads us in different cases, the formula of Launhardt (we do not speak here of the formula of Séjourné, which appears to us preferable to that of Launhardt, the discussion of the formulæ themselves not entering into the purpose of this paper) only expresses the rule now adopted in France, by which the limit of the work of metal is made lower as the accidental strains become relatively greater. Now this rule is evidently justified as much by the dynamic effects which these strains can produce as by the impossibility of determining the maximum value, especially in works intended to last a long time.

As to the formula of Weyrauch, which tends to reduce in large proportion the maximum coefficient of work when parts are exposed to frequent reversal of strains, it appears to us, even after the experiments of Bauschinger, to rest only upon assumptions altogether insufficient ; and we have the right to conclude from the behavior of rails that it leads in all cases to coefficients reduced much beyond the limit required by prudence.

Whatever opinion we may have as to the value of the formulæ of which we have spoken, there is in all these cases an element which should not be neglected in the study of metallic bridges ; it is the constitution of the girders themselves which we have to calculate. The hypotheses which have been made on the question of the repetition of strains in the parts are often so far removed from the truth that the coefficient of work of the metal to be adopted in calculations cannot safely be determined without taking account of this constitution.

* This calculation is made by assuming that the rail rests on six ties for a length of 5½ meters (18 ft.), or 12 for a length of 11 meters (36 ft.) ; the Orleans Company increases the number of ties one-sixth on its lines of heaviest traffic, but this change is made much more for the purpose of increasing the bearing and steadiness of the track than for diminishing the strain on the rails.

A Great Indian Bridge.

(From the *Indian Engineering*.)

The bridge over the River Ganges at Benares, lately completed by the Oude & Rohilkund Railroad Company, forms a most important link between the railroads in Oude and the Northwestern Provinces and the East Indian Railway. It brings Lucknow in direct railroad communication with Calcutta by a route 52 miles shorter than that *via* Cawnpore.

The junction with the East Indian Railroad at Mogul Serai will give the nearest route to the Punjab *via* the Oude & Rohilkund Railroad Company's new Northern Extension joining in with the Northwestern Railway at Saharunpore.

The bridge consists of 16 spans, viz., seven of 356 ft. and nine of 114 ft., measuring from center to center of piers. The larger spans extend from the north bank over the river, and the smaller spans are flood openings in case of overflow of the river on the south bank. The total length of the bridge from end to end of girders is 3,523 ft. The piers of the larger spans are founded on elliptical wells 65 ft. by 28 ft.

The piers of the smaller spans are each founded on two circular wells 12 ft. 6 in. in diameter, pitched 25 ft. center to center, and varying in depth from 63 to 152 ft. below ground level.

Both abutments are founded without well foundations—that at the south end having long wing-walls giving access to the bridge by a flight of steps on each side. On these abutments block-houses will be constructed for the military defence of the bridge.

The weight of the material used in one of the deep piers is about 16,000 tons. This enormous weight has, with the exception of the iron caisson and stone cap, been carried into place on coolies' heads along a narrow floating staging leading to each pier.

The girders are lattice built and are entirely of steel, the total weight of steel used in the 16 spans being 6,405 tons.

The girders were supplied by the Patent Shaft & Axletree Company, Wednesbury, England.

The main spans are the longest yet constructed in India, without the use of the cantilever form of girders, and the foundations of some of the main piers are the deepest in the world, being in some cases 140 ft. below water level.

The girders of the main span are 35 ft. in depth and 25 ft. apart, center to center. The traffic is carried between the girders of the main span and on top of the girders of the smaller spans, the road and the rail being of the same level, with footways on either side on cantilevers outside the main girders.

The girders of the smaller spans were utilized for erecting the main girders. Their length being one-third that of the main girders, it required three of the smaller girders to carry one of the larger, and therefore by erecting two temporary piers, one of the main openings was spanned by three smaller girders.

Work was carried on by day and night except during the very cold weather. The Gulcher system of electric lighting was in use, and worked most satisfactorily. It may be confidently stated, that without the assistance of electric light the bridge would not have been built, simply because it would be impossible without continuous night-work during the busy time to get through such work as must be completed to render the structure safe from flood during each season.

The first brick of this bridge was laid January 19, 1882, and it was ready for traffic in October, 1887.

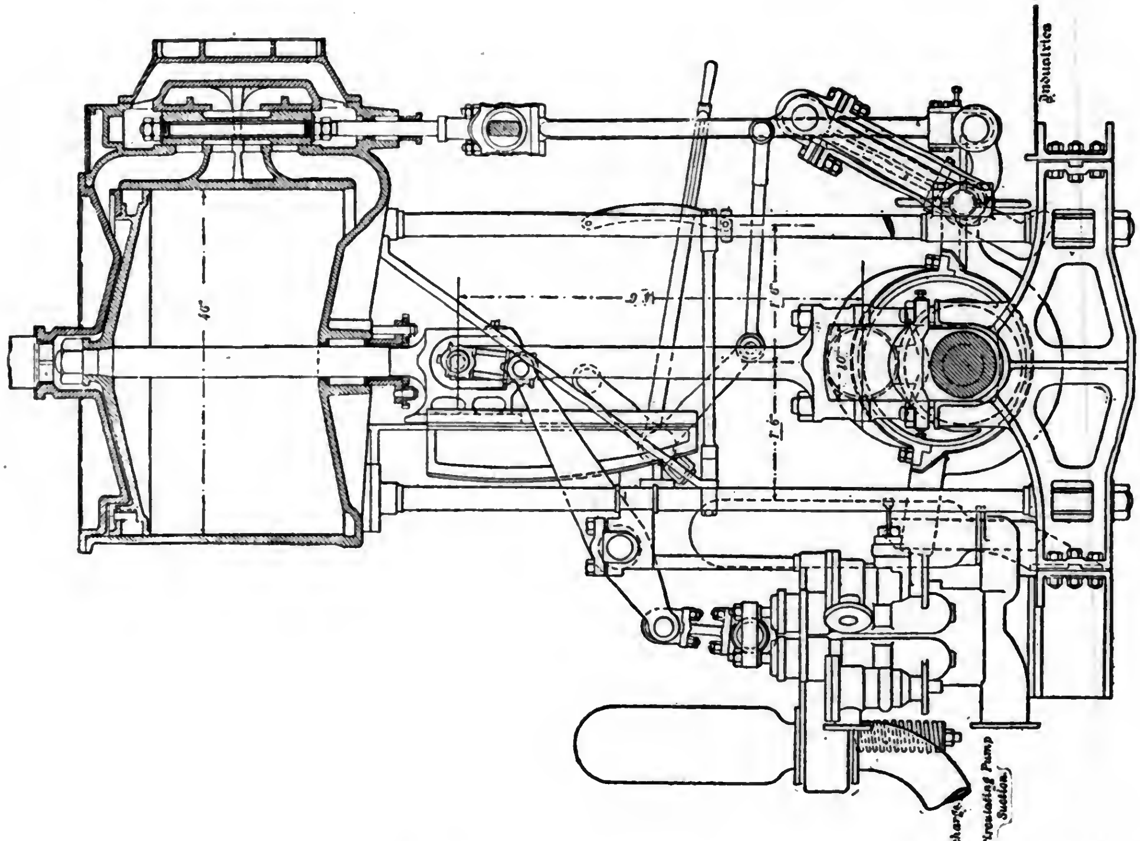


Fig. 2.

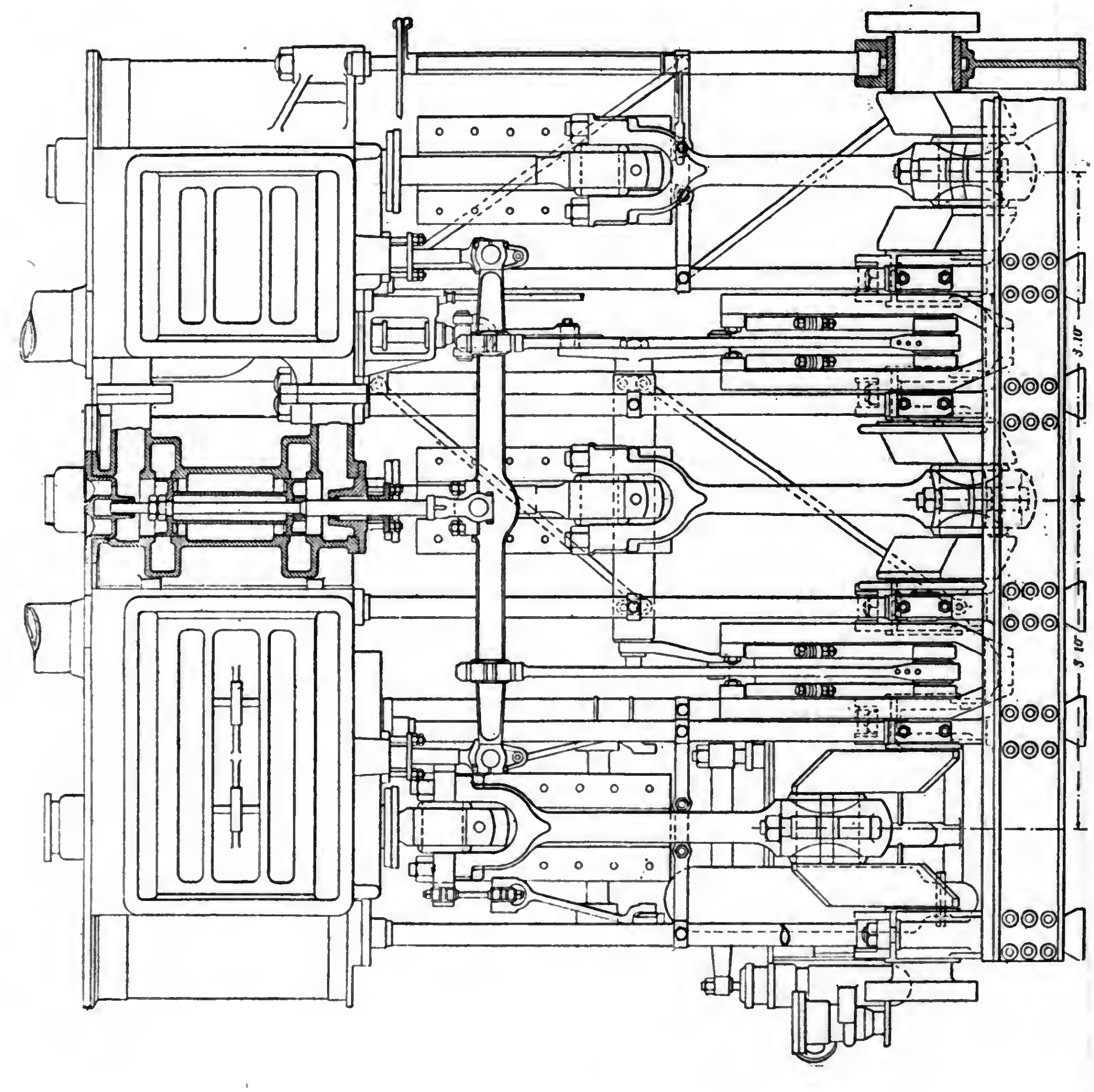


Fig. 1.

ENGINES FOR GUNBOAT "CERAM," DUTCH COLONIAL NAVY.

BUILT BY THE SCHELDE SHIPBUILDING AND ENGINEERING COMPANY, FLUSHING, HOLLAND.

Engines of a New Dutch Gunboat.

The accompanying illustrations (from *Industries*) show the engines and boilers of the new gunboat *Ceram*, recently built for the Dutch Colonial Navy by the Schelde Shipbuilding & Engineering Company at Flushing, Holland, Mr. W. H. Martin being the Engineer.

The engines are of the triple-expansion surface-condensing type, the cylinders being 20 in., 29 in., and 46 in. in diameter, and the stroke 29 in. The high-pressure cylinder is fitted with a liner of Whitworth compressed steel ½ in. thick, the space between the body of the cylinder and the liner being utilized for jacketing. The pistons are of cast steel, with junk rings of the same material, and fitted with Buckley's piston rings of much lighter section than usual. The slide valve of the high-pressure cylinder is cylindrical, and is made in that form for the purpose of bringing the inlet steam to the center of the valve. The intermediate and low-pressure valves are flat, but work under a strong cover, with false ports, for relieving them of the steam pressure. The valve arrangement consists of Bremme's gear, with the eccentrics on the couplings of the crank shaft. The vertical rods of the gear are connected by a ball joint to a floating lever, which actuates the three valves. For reversing the engines a reversing engine is used having a 7-in. steam cylinder, with 19-in. stroke, cast in one piece with the intermediate cylinder, and placed between this and the high-pressure cylinder. The piston rod of the reversing engine actuates, by means of a small connecting rod, a lever on the reversing shaft. The valve of the reversing cylinder is moved by a rod fixed to a hand lever, turning round a small eccentric on the reversing shaft, so that the valve is closed by a movement of the reversing shaft, equivalent to that given to the reversing handle. The reversing of the engines from full speed ahead to full speed astern is brought about in two seconds. The reversing shaft is carried in a pipe cast in one piece with the guide of the high-pressure cross-head. It will be seen from the illustrations that the pin forming the cross-head is attached by two bolts to the connecting rod. In this arrangement, the piston-rod ends are solid and without any cover, so that the brasses can be easily adjusted to the pin with the connecting rod disconnected. The brasses are closed up by a wedge worked by a screw from the front of the piston rod, this position being much more convenient than that of the nuts of the ordinary cover. The piston, connecting rods, and the crank shaft are made of steel, the latter being made in three equal parts. The corners of the crank webs are cut off, as shown, in order to reduce the weight. The bed-plate is made entirely of cast steel, and as light as possible while maintaining the necessary strength and rigidity; the total weight being only two tons. The foundation in the ship is formed by heightening the frames, and bending them into such a shape as to fit the bed-plate. The shaft brasses have no flanges, but are kept in place by pins fitting into holes bored in the bed-plate and cover. The eccentrics on the couplings are also without flanges, so as to leave the eccentrics free to move forward and backward with the shaft without bearing against the eccentric rings. The air and circulating pumps are single acting and cast in one piece. They are made of brass, while the feed and bilge pumps are of gun metal.

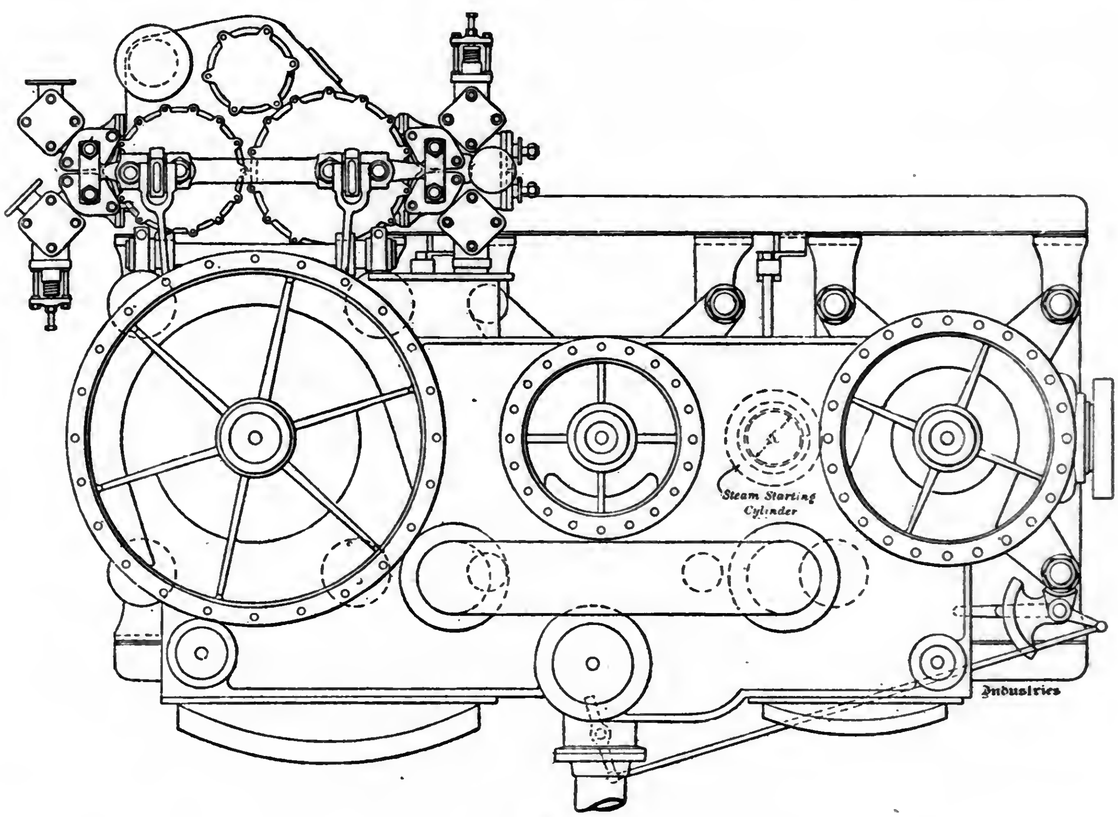


Fig. 3.

ENGINES FOR GUNBOAT "CERAM."

The columns supporting the cylinders consist of drawn-steel tubes 3 in. external diameter and ⅜ in. thick; but turned out of tubes ⅝ in. thick, to get the necessary thickness in places where holes had to be bored through them. At the ends where they fit into the bosses on the cylinders and bed-plate, they are forged to a smaller diameter, giving greater thickness of metal where the thread is cut. The condenser is made entirely of copper, the shell having corrugations at intervals, instead of the rings usually riveted on to it, to strengthen it against collapse; and the covers have radial corrugations for the same reason. Condensers made on this system are light, and have the additional advantage of having no rivet holes.

In the accompanying illustrations fig. 1 shows a front elevation of the engine (with section of the high-pressure cylinder); fig. 2 an end elevation (with section of the low-pressure cylinder), and fig. 3 a plan.

Steam is furnished by two double-ended boilers, 8 ft. 2 in. outside diameter and 15 ft. long, with one corrugated furnace 3 ft. 3 in. mean diameter. Each of these boilers

has 160 tubes 2¾ in. external diameter, and 40 stay-tubes 2¾ in. diameter and ¼ in. thick. Figs. 4, 5, and 6 show one of these boilers, fig. 4 being a longitudinal section, fig. 5 a half end-view, and fig. 6 a half cross-section.

The working pressure was fixed at 120 lbs. by the naval authorities, as, at the time when these engines were designed, a higher pressure was not customary, especially for ships stationed in the tropics. The boilers are made entirely of Siemens-Martin mild steel, all holes being drilled in position. The whole of the riveting was done by hydraulic riveters. It will be observed that the top of the combustion chamber is stayed in a rather unusual manner; but the builders think that this plan, or something equivalent to it, is the most effective way for strengthening this part of the boiler. They argue that so long as the boiler shell is utilized for staying the combustion chamber in the ordinary way, no other resistance can be obtained than that due to the stiffness of the shell plate, for the shell being in equilibrium may be deformed to a comparatively large amount before any considerable resistance is obtained. In the usual method of shaping the sides of the combustion chamber, the required tension on the stay-bolts is only effected by the two outer rows acting as struts and keeping the shell plate in its circular form, the part of the plate between these two rows acting as girders for the middle row of stays.

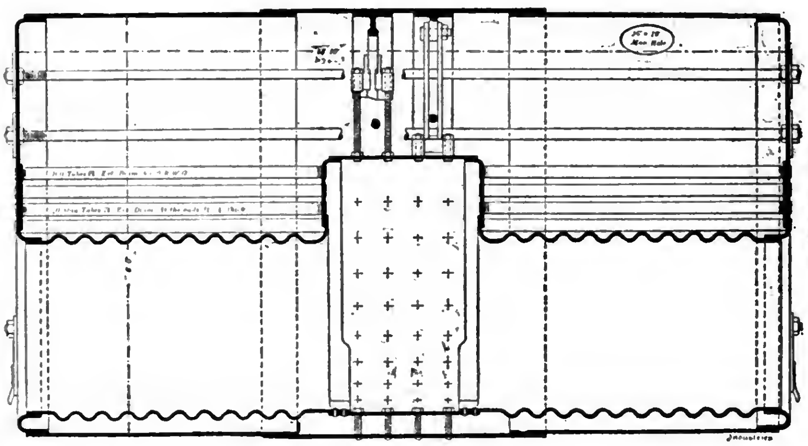


Fig. 4.

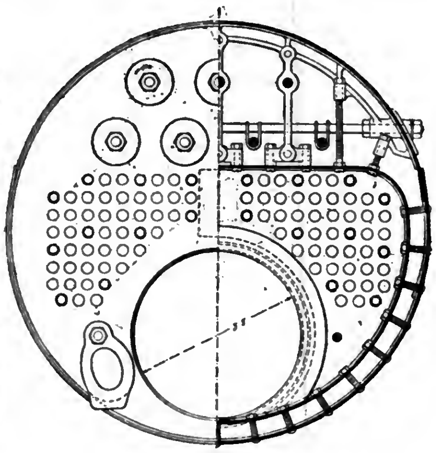


Fig. 5. Fig. 6.

BOILER FOR GUNBOAT "CERAM," DUTCH COLONIAL NAVY.

In boilers where steam pressures of 180 lbs. to 200 lbs. are to be used, this staying of the sides of the combustion chamber to the shell will have to be carefully attended to, otherwise leakages or accidents may occur. Referring to fig. 4, it will be observed that there are two bridge-stays in the middle of the breadth, which are arranged to allow a man to pass from one end of the boiler to the other. The bridges to which the vertical stays are attached have **I** section, and are made of cast steel, the outside being turned in the lathe to a true circle, and afterward riveted to the shell. Forced draft can be supplied by closing the stokeholds, the air being drawn from the engine-room and forced into the boiler space by a fan of 5 ft. 6 in. diameter, made by Messrs. Allen & Company, of London. An air pressure of 2 in. of water is easily obtained; but this pressure was not fully utilized on the trial trip. With about half that pressure the engines indicated 804 H.P., as against 606 H.P. obtained with natural draft.

The propeller is of Delta metal. The engines, when running at their full power and at 130 revolutions per minute, worked with very little vibration.

The gunboat *Ceram* is a composite vessel, sheathed with brass, and has the following dimensions: Length, 150 ft.; breadth, 25 ft. 6 in.; mean draft, 9 ft. 4 in.; displacement, 510 tons.

Electric Lighting of Cars in England.

THE Great Northern Railway Company has now four trains running from King's Cross in which, under the direction of Mr. James Radcliffe, the Telegraph Superintendent of the line, a most complete and efficient electrical plant has been fitted, and a fifth installation is in preparation for an express train to Edinburgh. A dynamo and set of accumulators are located in the van under charge of the guard, and a good idea may be formed of the simplicity of the arrangements from the following notice posted in the van:

"*Instructions to Guards.*—During daylight the switch is to be turned 'on' immediately the front brake enters a tunnel and 'off' directly the rear brake emerges from it. The light must be turned 'on' after sunset, five minutes before the train is due to leave the terminal station and on the approach of darkness when running, but must be turned off as soon as the passengers have left the carriages at the end of the journey."

Apart from the guard, all the attention necessary is that, before the starting of the train, an inspector sees that all is in order, and that the lubrication is properly provided for.

The machine found to be most suitable for the work is a Brush, shunt-wound, giving from 45 to 90 ampères of current, according to the speed at which the train travels. This is driven from the axle of the train wheels, multiplication of speed being obtained by means of countershafting introduced between the train axle and the pulley on the driving gear of the dynamo. The direction of rotation of the dynamo is regulated by friction cones, two on the shafting and another fixed on an extension of the dynamo spindle.

The two cones on the shafting are carried by a hollow shaft or sleeve, mounted and free to move on the driving shaft and furnished with spiral slots engaging with projections on the latter. By this means the opposite diameters of the cone on the dynamo spindle are automatically brought against either one or other of the cones on the shafting, according to the direction of the motion of the train, with the result that whichever way the train may be running the dynamo is always driven in one uniform direction, so that no reversal is needed, or any shifting of brushes or readjustment of any kind.

This arrangement has been designed and patented by Mr. Radcliffe. The accumulators are of the E. P. S. manufacture, "11 L" type, and are automatically connected with and disconnected from the dynamo by means of a switch or controller, also designed and patented by Mr. Radcliffe and manufactured by Messrs. Reid Brothers. When the train is at rest the lamps are fed from the accumulators, but when running, and when the E.M.F. of the dynamo rises above that of the accumulators, the dynamo is automatically connected to the accumulators and lamps, between which the current generated is divided, the accumulators taking the surplus over what is required for the lamps; when the speed slackens and the E.M.F. falls below that of the accumulators, the switch or controller automatically cuts the dynamo off, and the lamps are again fed from the accumulators.

A fusible cut-out is employed in such a way that in case of an accidental short circuit or mishap of any kind everything would be disconnected except the lamps with the accumulators, so that the lamps would run on. The cessation of light in any compartment is also guarded against by the system of wiring, a middle wire being run along the roof of each carriage, affording, in case of the accidental giving out of a lamp, a circuit by which the current finds its way to the rest of the lamps; and there being two lamps in each compartment, there is hardly a possibility of its being left in darkness.— *London Electrical Review.*

CATECHISM OF THE LOCOMOTIVE.

(Revised and enlarged.)

BY M. N. FORNEY.

(Continued from page 90.)

CHAPTER IX—CONTINUED.

THE LOCOMOTIVE BOILER.

QUESTION 207. *What must be the proportions for a single-riveted lap seam made of iron plates and with iron rivets to get the maximum strength?*

Answer. If the plates have a tensile strength and the rivets a resistance to shearing equal to 50,000 lbs. per square inch, THE RIVET HOLES (not the diameter of the rivets cold) SHOULD BE $2\frac{1}{3}$ TIMES THE THICKNESS OF THE PLATES, AND THE PITCH OF THE RIVETS FROM CENTER TO CENTER SHOULD BE 7 TIMES AND THE OVERLAP OF THE PLATES 6 TIMES THEIR THICKNESS. Fig. 124 represents a seam of these proportions. In the accompanying table the strength of a seam like that represented by fig. 118 is given in the vertical column *A*, and that of the one shown by fig. 124 is given in column *B*. The strength per lineal inch of the seams is given in the eighth horizontal line. That of the first one is 9,898 lbs., whereas that of the second one is 11,250 lbs. per lineal inch.

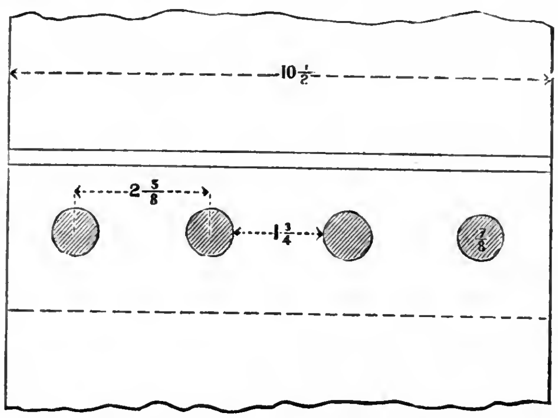


Fig. 124.

QUESTION 208. *What difference should there be in the proportions of single-riveted lap seams if made of steel instead of iron plates, and with steel rivets?*

Answer. As steel rivets with sufficient ductility have no greater strength to resist shearing than iron rivets, the one kind should be of the same size as the other; but as steel plates have about 20 per cent. more tensile strength than iron ones, the amount of metal between the rivet holes may be less if the plates are made of steel than if they are of iron. Thus in the seam represented by fig. 124 the rivet hole is $\frac{7}{8}$ in. in diameter, and the width of the metal between the holes is $1\frac{3}{4}$ in. Their sectional area and strength is as follows:

Rivet area, $.6013 \times 50{,}000 = 30{,}065$ lbs.

Plate area, $1\frac{3}{4} \times \frac{3}{8} = .65625 \times 50{,}000 = 32{,}812$ lbs.

If the plate is of steel and the space between the rivets is made $1\frac{3}{8}$ or 20 per cent. less than shown in fig. 124, then its strength would be as follows:

$$1\frac{3}{8} \times \frac{3}{8} = .5156 \times 60{,}000 = 30{,}937 \text{ lbs.},$$

or a little in excess of the strength of the rivets. THEREFORE, IF STEEL PLATES ARE USED THE PITCH OF THE RIVETS MAY BE 6 TIMES THE THICKNESS OF THE PLATES FOR A SINGLE-RIVETED LAP SEAM OF MAXIMUM STRENGTH.

The strength of a seam proportioned in this way is given in column *C* of the table, and is 22,500 lbs. per lineal inch. A comparison of the strength per lineal inch shows the advantage which is gained in strength by using larger rivets spaced further apart than those ordinarily used, and also the greater strength of seams made of steel plates.

QUESTION 209. *What other methods are there of making boiler seams which are stronger than those which have been described?*

Answer. In this country two rows of rivets are used and also what is called a "*welt*," or *covering-strip*, the latter with both single and double-riveted seams. What are called butt-joints or seams have been used a great deal in Europe, and of late years have been adopted to a limited extent in this country.

QUESTION 210. *How are the rivets arranged when two rows are used?*

Answer. They are sometimes placed just behind each other, as shown in fig. 125, which is called *chain-riveting*.

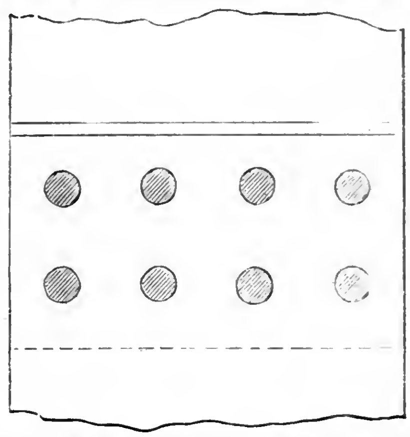


Fig. 125.

A much better arrangement is to place them alternately in the two rows, as shown in fig. 126. Rivets arranged in that way are said to be *staggered*, or placed *zigzag*.

In a single-riveted seam each rivet must resist a strain equal to that on the metal between two adjoining rivets. In a double-riveted seam one-half the strain on the metal between two contiguous rivets, in one row, is resisted by a rivet in the other row. Thus in fig. 126 the rivet *g* will take one-half the strain on the metal between the rivets *e* and *f*. Consequently the area of the metal between *e* and *f*, and their distance apart, may be very much greater than it would be in a single-riveted seam.

STRENGTH OF DIFFERENT KINDS OF RIVETED SEAMS.

		A	B	C	D	E	F	G	H	I
		Single-Riveted Lap Seam, Fig. 118.	Single-Riveted Lap Seam, Fig. 124.	Single-Riveted Lap Seam.	Double-Riveted Lap Seam, Fig. 126.	Double-Riveted Lap Seam.	Double-Riveted Lap Seam, Fig. 132.	Single-Riveted Lap Seam, Fig. 118, with Welt.	Single-Riveted Lap Seam, Fig. 124, with Welt.	Single-Riveted Lap Seam—with Welt.
1	Material of plates	Iron.	Iron.	Steel.	Iron.	Iron.	Steel.	Iron.	Iron.	Steel.
2	Diameter of rivet holes	$1\frac{1}{16}$ inch.	$\frac{7}{8}$ inch.	$\frac{7}{8}$ inch.	$\frac{3}{4}$ inch.	$\frac{7}{8}$ inch.	$\frac{7}{8}$ inch.	$1\frac{1}{16}$ inch.	$\frac{7}{8}$ inch.	$\frac{7}{8}$ inch.
3	Straight pitch of rivets	$1\frac{7}{8}$ "	$2\frac{5}{8}$ "	$2\frac{1}{4}$ "	3 "	$3\frac{5}{8}$ "	$3\frac{5}{8}$ "	$1\frac{7}{8}$ "	$2\frac{5}{8}$ "	$2\frac{5}{8}$ "
4	Diagonal pitch of rivets	....	....	....	$2\frac{1}{4}$ "	$2\frac{3}{4}$ "	$2\frac{3}{11}$ "	....	....	....
5	Strength of rivets to resist *shearing*	74,240 lbs.	131,250lbs.	131,250lbs.	132,010lbs.	180,390lbs.	180,390lbs.	148,480lbs.	262,500lbs.	262,500lbs.
6	Strength of plates through rivet holes to resist *tearing*	89,060 "	120,260 "	123,748 "	126,562 "	182,810 "	177,185 "	114,840 "	153,070 "	163 120 "
7	Strength of plates in front of rivets to resist *crushing*	92,812 "	118,125 "	118,125 "	151,875 "	177,183 "	177,183 "	185,624 "	236,250 "	236,250 "
8	Minimum strength of seam per lineal inch	9,898 "	11,250 "	13,125 "	14,062 "	14,318 "	16,874 "	15,312 "	14,578 "	18,124 "
9	Strength of plate per lineal inch	18,750 "	18,750 "	22,500 "	18,750 "	18,750 "	22,500 "	18,750 "	18,750 "	22,500 "
10	Strength of seam in percentage of solid plate	52.78	60.	58.33	74.46	76.36	75.	81.66	77.75	80.55

QUESTION 211. *What are the usual proportions for double-riveted seams?*

Answer. The following table, copied from "The Elements of Machine Design," by W. C. Unwin, gives proportions for such seams which are very commonly used:

PROPORTIONS FOR DOUBLE-RIVETED SEAMS.

Iron Plates, Iron Rivets.			Steel Plates, Iron Rivets.		
Thickness of Plates.	Diameter of Rivets.	Pitch of Rivets.	Thickness of Plates.	Diameter of Rivets.	Pitch of Rivets.
3/8 inch.	3/4 inch.	3 inch.	3/8 inch.	3/4 inch.	2 7/16 inch.
7/16 "	13/16 "	3 1/16 "	7/16 "	13/16 "	2 1/2 "
1/2 "	7/8 "	3 1/8 "	1/2 "	7/8 "	2 9/16 "
9/16 "	7/8 "	3 1/8 "	9/16 "	7/8 "	2 9/16 "
5/8 "	15/16 "	3 3/16 "	5/8 "	15/16 "	2 5/8 "
3/4 "	1 1/16 "	3 5/16 "	3/4 "	1 1/16 "	2 3/4 "
7/8 "	1 1/8 "	3 3/8 "	7/8 "	1 1/8 "	2 13/16 "
1 "	1 1/4 "	3 1/2 "	1 "	1 1/4 "	2 15/16 "

QUESTION 212. *What should be the diagonal pitch of the rivets in a double-riveted seam—that is, the distance between the centers of the rivets c and g or g and f of fig. 126?*

Answer. It has been found by experiment* that the net metal measured on a zigzag line, *c g f*, fig. 126, should be about one-third in excess of that measured straight across. If there is not that much excess the plates will be weaker straight across, and will break on the line *a b*. IF THE DIAGONAL PITCH (or the distance from center to center of rivets *c* and *g* or *g* and *f*) IS MADE THREE-QUARTERS OF THE PITCH OR DISTANCE BETWEEN THE CENTERS OF RIVETS (*c* and *f*) ON THE SAME LINE, it will give a good proportion for such a seam.

QUESTION 213. *How should a double-riveted seam be proportioned to have the maximum amount of strength?*

Answer. To proportion such a seam the rivet hole, for the reasons explained, should be taken of the same diameter as for a single-riveted seam—that is, 2¼ times the thickness of the plates. For plates ⅜ in. thick the rivet holes would therefore

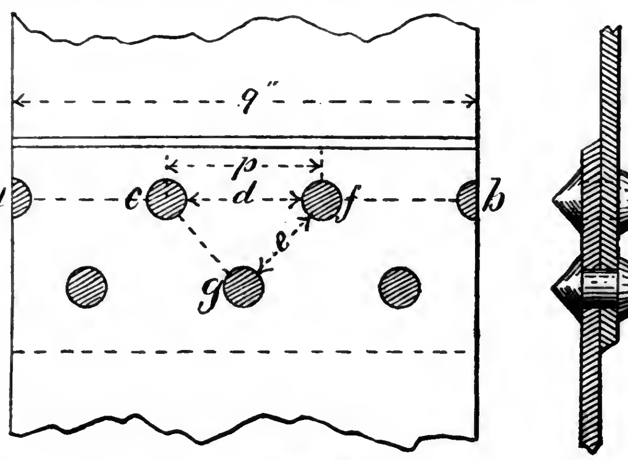


Fig. 126.

be ⅞ in. diameter. It has been explained, and is shown in fig. 126, that in a seam with two rows of rivets the rivet strength—that is, their resistance to shearing, is twice that of a seam with one row, because the number of rivets is doubled. Consequently the amount of metal between the rivets may be twice as great as in a single-riveted seam. It has been found by experiment and calculation that if the diameter of rivets for a double-riveted seam is made 2¼ times the thickness of the plates, and the pitch—with iron plates—is made 11 times, and for steel plates 9⅓ times their thickness, that it will give a seam of nearly equal strength to resist the shearing of the rivets and the tearing and crushing of the plates.

The strength of such seams has been calculated, and the results are given in columns *E* and *F* of the table. Column *D* gives the strength of a seam, represented by fig. 126, and proportioned as specified in the table of proportions for double-riveted seams. The strength of these per lineal inch in the eighth horizontal line of the large table shows the superiority of double-riveting, and also the gain from the use of large rivets and greater pitch and of steel plates.

The distance that the rivets should be spaced on a zigzag line is three-quarters of the pitch on a straight line, or 8¼ times the thickness of iron and 7 times that of steel plates.

QUESTION 214. *What is the form of construction of boiler seams made with a lap and a welt or covering-strip?*

Answer. The plates (*a*, *b*, fig. 127) are lapped over each other as for an ordinary seam. Another plate, *c*, is then placed on the inside of the seam and bent so as to conform to the lap of the two plates. The rivets *r r*, whether a double or single row, pass through all three plates, and two more rows

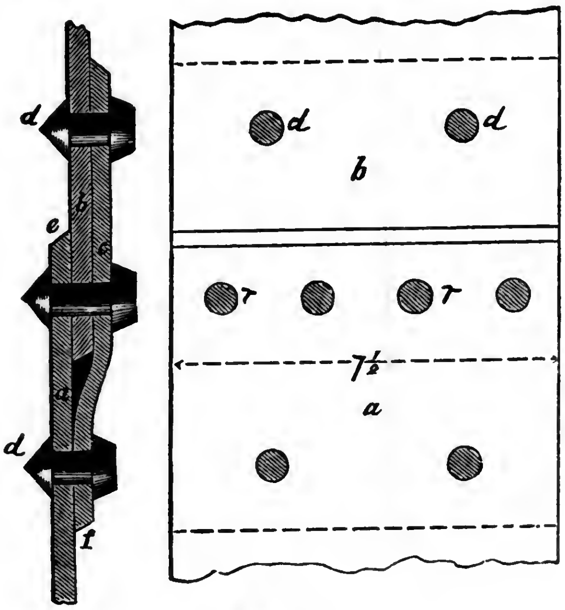


Fig. 127.

of rivets, *d d*, are put next to the edges of the covering plate, *c*. It is plain that the strength of the seam, *r*, is increased up to a certain point by an amount just equal to that of the rivets in the edges of the covering plate. If, however, these are placed too close together, the plates *a* and *b* will be weaker through the outside rows of rivets, *d d*, than the seam is through either of the outside ones and the middle one taken together. If, for example, we take a single-riveted seam, like that shown in fig. 118, whose strength is only a little more than half that of the solid plate, and should add to it a covering plate, as shown in

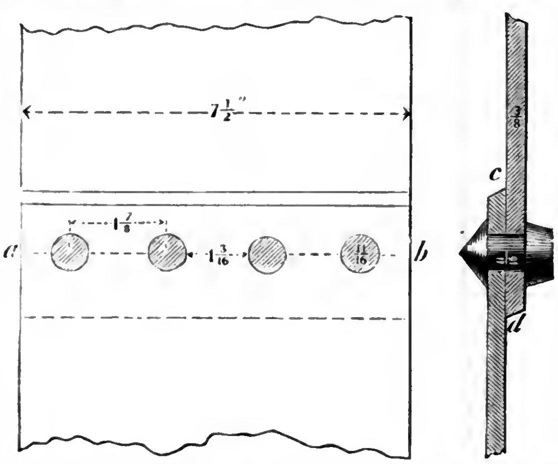


Fig. 118.

fig. 127, and then space the rivets in the edges of the covering plate the same distance apart as in the middle seam, then obviously the plates would be just as liable to break through the outer rows of holes as through the center row before the covering plate was added. If, however, the holes in the two outside plates are spaced at say twice the distance apart, or 3¾ in., then the only way the seam can break through the outer rows of holes is by shearing the rivets, because the plates between the holes are then stronger than the rivets. But before these rivets can be sheared, the center seam must give way. Thus the strength of such a seam is equal to THE SUM OF THE STRENGTH AT THE WEAKEST POINTS OF THE MIDDLE AND THE OUTSIDE SEAMS. The strength of the plates between the holes of the

* See "Report upon Experiments and Abstract of Results of Experiments on Riveted Joints" in *Proceedings* of the Institution of Mechanical Engineers for April, 1885.

outside rows of rivets must, however, be as great as the sum referred to, otherwise the seam will be the weakest at that point, and the failure will occur there. The rivets in the outside rows should be spaced at least twice as far apart as those in the middle seam. The number of rivets to resist shearing will then be 50 per cent. greater than in a single-riveted seam. Welted seams of this kind are sometimes made with a double row of rivets between the two outer rows.

QUESTION 215. *What advantage has such a seam over seams without a welt?*

Answer. The strength of a seam is increased by an amount equal to that of the welt. Thus, column *G* gives the strength of a seam like that in column *A* with a welt added, column *H* gives the strength of seam *B* with a welt, and column *I* gives the strength of seam *C* welted. A comparison of the strength of the different seams per lineal inch in the eighth horizontal line shows the great increase in strength which results from the addition of a welt.

QUESTION 216. *How are butt-joints or seams made?*

Answer. In these the ends of the two plates abut against each other, as shown at *a* in figs. 128 and 129, with a covering strip

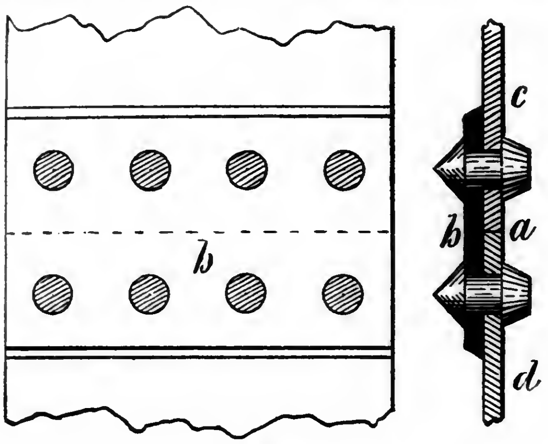


Fig. 128.

or welt—which is shaded black in the engraving—on one or both sides. In some cases a single welt or covering strip, *b*, fig. 128, is used with either two or four rows of rivets. Such a seam has no more strength than a lap seam like those shown by figs. 118 or 126. In fact, it consists of two lap seams. The circumferential seams of boilers are, however, often made in this way in Europe, so as to get all the plates in the cylindrical part of the boiler flush with each other.

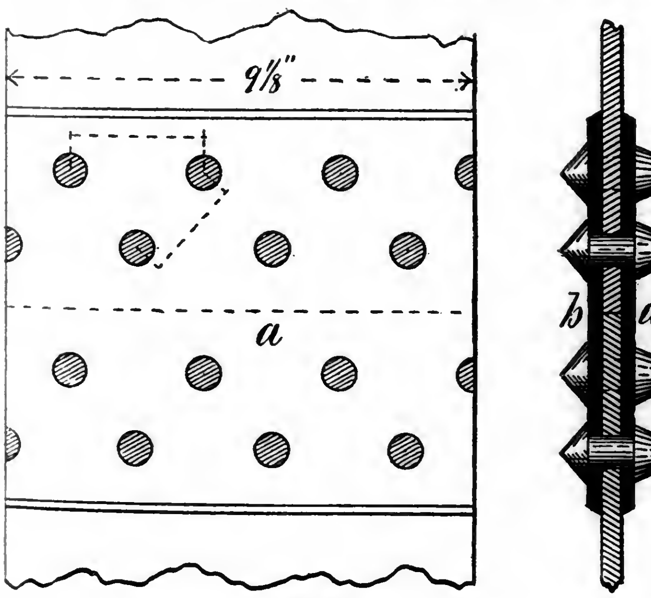


Fig. 129.

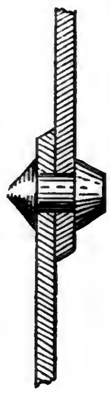
QUESTION 217. *What is the strength of butt seams or joints compared with those which have been described?*

Answer. A butt seam with double strips and quadruple rows of rivets is little, if any, stronger than a double-riveted lap seam properly proportioned. The resistance to the crushing action of the rivets limits the strength of both kinds of seams, and in that respect they may be nearly equally strong.

QUESTION 218. *What advantages have butt seams with double welts, as shown in fig. 129?*

Answer. Such seams are often used for the longitudinal seams of boilers because a lap seam like that shown in fig. 130, when subjected to a tensile strain, will tend to draw into the form shown in fig. 131—that is, the tendency is to draw into a straight line, and a bending strain will be exerted on them at *a* and *b*. This strain also tends to pull the plates apart where they lap over each other, whereas in a seam like that shown in fig. 129 the strain on the plates and on the covering strips *a* and *b* is in a line parallel with their surfaces, and therefore no bending action is exerted on them. It is found by experience that boilers are very often corroded along the edges of the plates of lap seams just where the bending action takes place. It is probable that when iron or steel is subjected to a high degree of tension, and at the same time exposed to substances which corrode them, that their action is most rapid where the strain is greatest. At any rate, it is found that much less corrosion occurs with butt seams which have double welts than with lap seams.

Fig. 130.



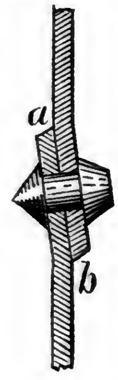


Fig. 131.

QUESTION 219. *What are the proportions commonly used for butt seams?*

Answer. The following table is from Wilson's "Treatise on Steam Boilers," and gives the proportions for double-riveted butt joints which are very commonly used:

PROPORTIONS FOR DOUBLE-RIVETED BUTT JOINTS WITH DOUBLE STRIPS.

Thickness of Plate.	Diameter of Rivet.	Thickness of Strip.	Pitch of Rivets.
⅜ inch.	⅝ inch.	¼ inch.	2½ inch.
$\frac{7}{16}$ "	⅝ "	¼ "	2⅝ "
½ "	⅝ "	$\frac{5}{16}$ "	2¾ "
$\frac{9}{16}$ "	$\frac{11}{16}$ "	$\frac{5}{16}$ "	2⅞ "
⅝ "	¾ "	⅜ "	3 "
$\frac{11}{16}$ "	¾ "	⅜ "	3⅛ "
¾ "	⅞ "	$\frac{7}{16}$ "	3¼ "
$\frac{13}{16}$ "	⅞ "	$\frac{7}{16}$ "	3½ "
⅞ "	1 "	½ "	3⅝ "
$\frac{15}{16}$ "	1 "	½ "	3¾ "
1 "	1⅛ "	$\frac{9}{16}$ "	4 "

QUESTION 220. *How should a quadruple-riveted butt seam with double strips of maximum strength be proportioned?*

Answer. The diameter and pitch of rivets should be proportioned in the same way as for a double-riveted lap seam. A butt seam has usually an excess of rivet area to resist shearing, because the rivets are subjected to a double shear. The strength of such a seam is, however, limited by the resistance of the metal in front of the holes to crushing. There is, therefore, not much difference in the strength of well-proportioned double-riveted lap and butt seams.

QUESTION 221. *What influence does the size of the rivet-heads and ends have on the strength of a seam?*

Answer. It has been found that an increase of about one-third in the weight of the rivets (all this increase going to the heads and ends) was found to add about 8½ per cent. to the resistance of the joint. RIVETS, BEFORE THEIR HEADS ARE FORMED, SHOULD PROJECT BEYOND THE PLATES A DISTANCE EQUAL TO ABOUT 3 TIMES THEIR DIAMETERS TO GIVE SUFFICIENT MATERIAL FOR THE HEADS.

QUESTION 222. *What practical consideration must govern the proportions of riveted seams?*

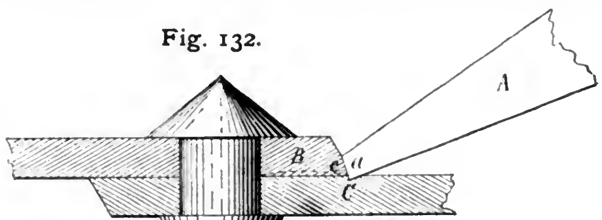
Answer. It must be determined what is the greatest pitch of rivets which can be used in any particular case. Generally it becomes a question of how wide a pitch can be used and the

boiler be made tight by caulking. The proportions for riveted seams given in the tables are such as have been extensively used in practice. With improved material and workmanship, doubtless larger rivets than the sizes given in the tables can be used, and they can be spaced farther apart and still make a tight joint, and a nearer approximation can be made to the dimensions given by the rules for proportioning seams of maximum strength.

QUESTION 223. *How are the seams of boilers made tight?*

Answer. By what is called *caulking*—that is, by the use of a blunt instrument, *A*, fig. 132, somewhat resembling a chisel, the end, *a*, of which is placed against one of the edges of the plate *B*, which is then compressed or riveted down by blows of a hammer, somewhat as the joints between the planks of a ship are made tight. The edges, *e*, of the plates—called the *caulking edges*—are sometimes planed before they are put together, but

Fig. 132.



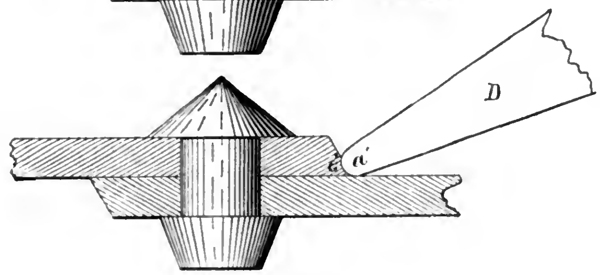


Fig. 133.

more commonly they are cut or trimmed off with a chisel. In this process the plate is often injured seriously by the carelessness of workmen, who sometimes allow the chisel to cut a groove in the plate at *C*, under the edge, thus weakening it at a point where the greatest strength is needed. If driven too hard the tool is liable to force the plates *B* and *C* apart, as indicated by the dotted line below *B*. For these reasons Mr. Connery, foreman of the boiler shop of the Baldwin Locomotive Works in Philadelphia, devised a system of caulking with a tool, *D*, having a round nose, *a'*, as shown in fig. 133. With this there is no liability to groove the lower plate nor force the plates apart.

QUESTION 224. *How much water is usually carried in a locomotive boiler?*

Answer. There must always be enough water in the boiler to cover completely all the parts which are exposed to the fire, otherwise they will be heated to so high a temperature as to be very much weakened or permanently injured. In order to be sure that all the heating surface will at all times be covered with water, it is usually carried so that its surface will be from 4 to 8 in. above the crown-sheet.

QUESTION 225. *How much space should there be over the water for steam?*

Answer. No exact rule can be given to determine this. It may, however, generally be assumed that the more steam space the better. In order to increase the steam room, locomotive boilers are very generally made in this country with what is called a *wagon-top*, shown in fig. 90—that is, the outside shell of the boiler over the fire-box is elevated at *X* from 4 to 12 or even 18 in. above the cylindrical part.

QUESTION 226. *What is a steam-dome, and for what purpose is it intended?*

Answer. A *steam-dome, U U*, fig. 90, is a cylindrical chamber made of boiler-plate and attached to the top of the boiler. Its object is to increase the steam room and to furnish a reservoir which is elevated considerably above the surface of the water, from which the supply of steam to be used in the cylinders can be drawn. The reason for drawing the steam from a point considerably above the water is that during ebullition more or less spray or particles of water are thrown up and mixed with the steam. When this is the case, steam is said to be *wet*, and when there is little or no unevaporated water mixed with it it is said to be *dry*. It is found by experience that wet steam is much less efficient than that which is dry. There is also danger that the cylinders, pistons, or other parts of the machinery may be injured if much water is carried over from the boiler with the steam, because water will be discharged so slowly from the cylinders that there is not time when the engine is running fast for it to escape before the piston must complete its stroke, so that the cylinder-heads will be "*knocked out*," or the cylinder itself or the piston will be broken. The reason for drawing or "*taking*" steam from a point considerably above the water is because there is less spray there than there is near the surface, and the hottest steam, which is also the dryest, ascends to the highest part of the steam space.

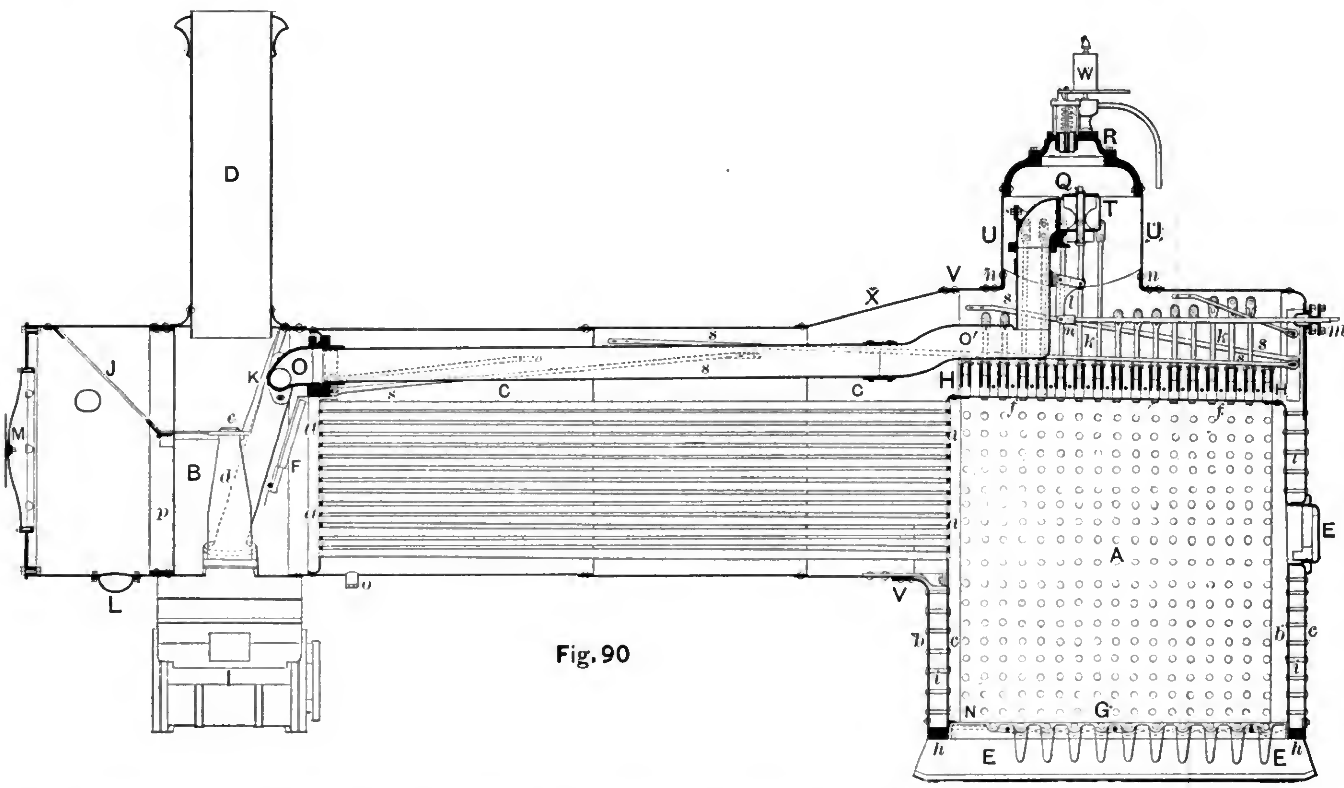


Fig. 90

QUESTION 227. *Where is the dome usually placed?*

Answer. In this country it is usually placed over the fire-box, but in Europe it is often placed further forward, either about the center of the boiler or near the front ends of the tubes.

QUESTION 228. *How is the steam conducted from the dome to the cylinders?*

Answer. By a pipe, *T C' O*, fig. 90, called the *dry-pipe*, which extends from the top of the dome to the front tube-plate. On the front side of the tube-plate and inside the smoke-box two curved pipes, called *steam-pipes*, are attached to the dry-pipe at one end, and to the cylinders at the other. The vertical portion, *Q*, of the dry-pipe in the dome, sometimes called the *throttle-pipe*, is usually made of cast iron, the horizontal part of wrought iron, and the steam-pipes of cast iron.

QUESTION 229. *How is the loss of heat from locomotive boilers by radiation and convection prevented?*

Answer. Usually by covering the boiler and dome with wood, called *lagging*, about ⅞ in. thick, which is a poor conductor of heat, and then covering the outside of the wood with

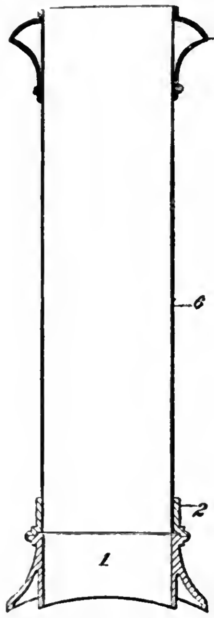


Fig. 134.

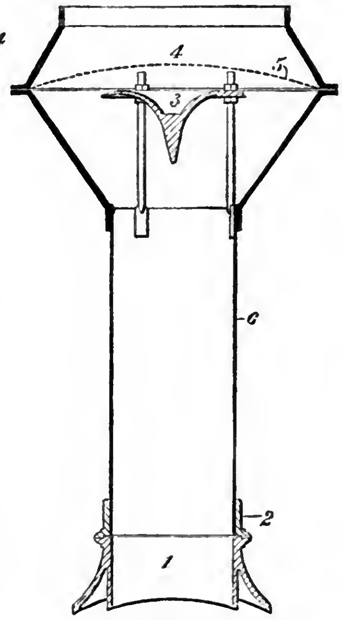


Fig. 135.

Russia iron, the smooth, polished surface of which is a poor radiator of heat. Sometimes locomotive boilers are first covered with felt and then with wood and Russia iron. Recently plastic material, which hardens after it is applied to the boiler, has been used a good deal. This is also covered with Russia iron.

QUESTION 230. *What is the smoke-box for?*

Answer. The smoke-box *B* is simply a convenient receptacle for the smoke before it escapes into the chimney or smoke-stack, which is attached to the top of the smoke-box. It also affords a convenient place for the steam and exhaust-pipes, where they are surrounded with hot air and smoke, and not exposed to loss of heat by radiation.

Formerly smoke-boxes were made without the portion shown in fig. 90, which extends in front of the ring *p*. This part, called the *extended front end*, has been added to give room for appliances to arrest the sparks. These consist of a deflector, *F*, in front of the tubes and wire netting, *J K*, which cause the heavy sparks and cinders to be thrown forward, and prevent them from being carried up the chimney. They are thus deposited in the front end, from which they can be removed by a suitable aperture, *L*, at the bottom.

The front of the smoke-box is usually made of cast iron, with a large door, *M*, in the center, which affords access to the inside.

QUESTION 231. *How are the chimneys or smoke-stacks of locomotives constructed?*

Answer. The forms of smoke-stacks which have been used are almost numberless. When an extended front-end, such as is shown in fig. 90, is used, the chimney often consists of merely a straight pipe, *D*, as represented. A larger drawing of this stack is given in fig. 134. For burning bituminous coal and wood, what is called a *diamond stack*—probably from the shape of the outline of the top—as shown in fig. 135, is used a great deal. This consists of a central pipe, 1, 4, fig. 135, and a conical-shaped cast-iron plate, 3, called the *cone* or *spark deflector*, which, as the latter name implies, is intended to deflect the motion of the sparks and cinders which are carried up with the ascending current of smoke and air in the pipe 1, so as to prevent them from escaping into the open air while they are incandescent, or "alive." A wire netting, 5, is also provided, which is intended as a sort of sieve to enclose the sparks and cinders, and at the same time allow the smoke to escape. The receptacle below the cone is intended as a chamber in which the burning cinders will be extinguished before they escape. For burning anthracite coal, a simple straight pipe, as shown in fig. 134, without a deflector or wire netting, is ordinarily used. For burning wood a chimney or smoke stack of the form shown in fig. 135 is sometimes used, but more generally one of the form shown in fig. 136, which is a wide stack, with a straight interior pipe 8, a cone 3 and wire netting 5. Inside the outer shell 6 there is an inner box or bonnet 7. The sparks collect in the space outside the straight pipe 8, and can be removed through the hand-hole 9.

QUESTION 232. *What are the proportions and materials usually employed in the construction of smoke-stacks?*

Answer. The inside pipe 6, fig. 135, is usually made of the

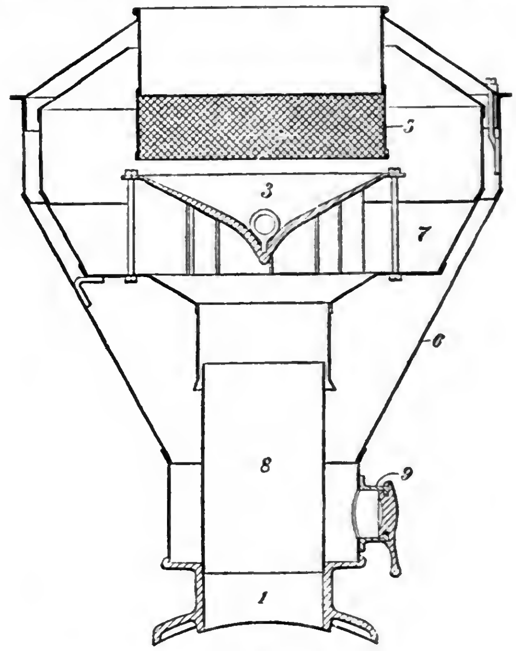


Fig. 136.

same diameter as the cylinders, or an inch or two smaller. For the other dimensions there are no established rules, excepting for the height of the top of the chimney above the rail, which is usually from 14 to 15 ft. The outsides of smoke-stacks are made of sheet iron, but the upper part is now sometimes made of cast iron, so as to withstand the abrasion of the sparks and cinders longer than sheet iron will. For very warm and damp climates, the outsides of smoke-stacks are sometimes made of copper to resist corrosion, which is very destructive to all iron structures in those countries. The wire netting is made of iron or steel wire from $\frac{1}{16}$ to $\frac{1}{30}$ in. in diameter, and with from 3 to 4 meshes to the inch.

(TO BE CONTINUED.)

The Suram Tunnel in Russia.—A letter from a correspondent at Suram, addressed to the *Novoe Vremya*, contradicts the rumor that has circulated of late denying that Russia had seriously taken in hand the construction of a tunnel through the ridge of the Lesser Caucasus, between Batoum and Tiflis. According to this correspondent, fair progress has already been made at one end of the tunnel, the excavation having already penetrated over 1,000 ft., while at the other 200 ft. of rock have been cut away. The boring machines are of the latest description, and every improvement in tunneling is being adopted. The total length of the tunnel will be 11,460 ft., and it is expected that it will be finished by the end of next year. The cost, with that of the loop line, will exceed $5,000,000. The tunnel at one part passes through clay and will require to be lined with stone, but a good deal consists of solid rock, which requires to be blasted by dynamite. Pending the construction of the new line, the traffic over the Suram Pass still continues in a very congested condition. To relieve the congestion the Government has sanctioned the laying of pipe lines, 37 miles long, over the pass. Messrs. Nobel & Rothschild have already received permission to lay down pipe lines of their own, and other competitors are in the field.

The improvement of the line from Batoum to Tiflis is of interest here, as any increase in the facilities of transportation will increase the power of the Russian producers to compete with American petroleum in the European markets.

Manufactures.

The Sibley Bridge Over the Missouri.

THE latest of the great bridges over the Missouri River has just been completed at Sibley, near Kansas City, for the use of the new Chicago, Santa Fé & California Railroad. The surveys for this bridge were begun early in January, 1887, and the location finally adopted was at the lower end of the Sibley Bend. At this point the engineers found a shelf of rock extending across the river only 30 ft. below the water level. Just above this shelf of rock there crops out on the shore a remarkable object which has long been a land mark of the Missouri, and which is a huge mass of boulders of granite, porphyry, and metamorphic sandstone. It has long been considered as really the terminal moraine of an ancient glacier, and the boulders of which it is composed have probably been brought by the ice from the Lake Superior region.

The borings made by the engineers across the bottom lands to the bluffs on either side of the river valley show that while the bed-rock is near the surface, under the river it was abraded to a depth of from 100 to 120 ft. under the present level of the bottom land, showing that at this point the valley had not been excavated through the bluffs by the present force of the river, but really worn down by glacial action.

The plan adopted for the bridge required the erection of eight piers, including the abutments. Of these piers Nos. 1 and 2, on the south side, were founded upon the natural soil. Nos. 3, 4, 5, 6, and 7 were built upon caissons carried down to the bed-rock. These caissons were all sunk by the pneumatic method, and some unusual difficulties were experienced from the extremely rapid current of the river and from the number of boulders found in the soil above the bed-rock, through which they had to be sunk. Piers 3, 4, and 5, which carry the river spans, are 122 ft. high from bed-rock to the bridge seat. Pier No. 8 of the north abutment was founded on piles. All the piers are built of cottonwood stone; this stone is not affected by the weather, but as a measure of precaution the 12 ft. adjoining the water line were built of granite, and the cap-stones of the piers are also made of Iowa granite.

The bridge is made up as follows, beginning on the south side of the river: One deck span of 200 ft.; three through spans of 400 ft. each over the river; one deck span of 250 ft. and two of 175 ft. each over the sand-bar; 1,900 ft. in length of iron viaduct over the bottom land, making a total length of bridge of 3,900 ft. In addition to this there is a further length of 3,600 ft. of wooden trestle across the bottom lands which is to be filled up and made a solid embankment.

The bridge was built under charge of Mr. A. A. Robinson, Chief Engineer, with Mr. Octave Chanute as Consulting Engineer. The immediate charge of the work rested upon John Wallace, Resident Engineer, with Otto Sonne and G. J. Bell as assistants. The substructure was built by Sooysmith & Company, of New York; the contractor for the superstructure was the Edge-Moor Iron Company, of Wilmington, Del.

The 400 ft. spans are of steel, the rest of the structure and the viaduct being of iron.

A remarkable feature about this bridge was the short time in which it was built. Work was actually begun April 8, 1887, and the bridge was open for travel January 25, 1888, the whole time employed being 293 days only, less than has been required for the erection of any other bridge over the Missouri. It was originally intended to have the bridge completed by January 1, but the delay was due partly to the unusual height and the rise of the river in June, which delayed the work of sinking the caissons, and the very stormy weather the latter half of December, which interrupted the work on the erection of the superstructure.

The total cost of the bridge was $800,000, a little over $200 per linear foot. This is by no means large, considering the length of span adopted over the river.

Electric Street Railroads.

THE *Electrical Review* gives the following summary of progress made during 1887 in relation to electric motors and railroads:

"The year 1887 has been eminently fruitful in the large number of electric railroads undertaken and in the new systems brought out. In so far as the electric motors themselves are concerned, a number have made their appearance, which, as in the case of the dynamo, chiefly present modifications of details intended to increase their efficiency, and among which we may mention those of Baxter, Immisch, Silvey, the Cleveland, Card, Hyer, Thone, C. & C, etc.

"But in the department of railroad work sufficient has been done to warrant a more detailed description in not a few cases. Thus early in the year Mr. Stephen D. Field made public a system of his which is designed especially for street railroad work. In this system two conduits are employed, the tops of which form the bearings for the rail, the flange on the wheel entering the slot in the top. In each of these conduits an insulated conductor is placed, each one of which is connected to a dynamo placed at each end of the line. The conductor in one conduit is connected with the positive brush of the dynamo, the negative brush of which is connected to the ground; and the other conductor is connected to the negative brush of the dynamo at the other end of the line, the positive brush being connected to ground. By this means two potentials can be obtained, viz., that between the two conductors themselves—that is, between the positive and negative brushes of the two dynamos; or, the difference of potential due to one dynamo alone. The one potential is obtained by connecting across the two conductors themselves, while the second, lower potential, is obtained by connecting one conductor and the ground. Thus, in case of the failure of one machine, the other is still able to maintain traffic on the line; by this arrangement also the resistance of the line is kept uniform, no matter what may be the position of the car upon it. Mr. Field has also carried out a series of experiments with a motor designed especially to be employed on the elevated railroads in New York City. The connection between the armature shaft and the driving-wheels is a direct one, the ordinary locomotive parallel bar being employed for that purpose.

"Another system which deserves attention is the series electric railroad system of Short & Nesmith, which has been put in operation at Denver, Col. In this system the current is kept constant, instead of the potential, as usual, and the car as it travels along makes and breaks contacts, which forces the current to pass through the motor on the car.

"To avoid the use of a slotted conduit, several systems have been brought out during the year in which the electric connection between the car and the conductor is effected without the employment of a slot. Among these we may mention that of Pollak and Binswanger. In this system an insulated conductor is buried in the ground, and at suitable short intervals branches are laid into switch-boxes, which are placed directly under a conducting rail upon the surface. Contact wheels bear upon these conducting rails which normally have no current passing in them. Upon the car, however, is carried a magnet which acts upon an armature placed in the contact boxes below the surface, and by the attraction of which the armatures are raised. This closes a contact which connects the surface conducting rail with the main insulated conductor below the surface, which then furnishes current to the motor on the car. As soon as the car has passed these points, the armature in the contact box is released, and the connection broken, whereupon a similar connection takes place at the next contact box; and thus a continuous current for the motor is obtained. Hence the surface conducting rail only affords a local circuit and may be said to be a traveling conductor, energized only at the point where the car happens to be at any particular moment.

"Another device intended to overcome the use of a slot is that of Irish, in which a flexible conduit permits connection to be made with a surface conducting rail and the conductor within the conduit.

"We must also mention here the elevated railroad experiment of Sprague, as well as the system of Enos, designed for elevated railroads. Not a little attention has been devoted during the year to the various methods of gearing the motor to the axles of the car, and an excellent *résumé* of these has been given by Mr. A. Reckenzaun before the American Institute of Electrical Engineers. Before that body, also, a valuable statistical table of the electrical railroads of America and Europe has been given by Mr. T. C. Martin. It is specially worthy of note that the year has seen the inauguration of the first mine railroad in this part of the world, that of Schlesinger, in the Lykens Valley coal mine, the success of which will no doubt lead to the construction of numerous others in the future."

Manufacturing Notes.

THE Linden Steel Company in Pittsburgh has finished the armor-plates for the new cruiser *Baltimore*, and is now at work on the plates for the *Newark*. The armor-plates are of steel, 4 in. thick, and most of them 18 ft. long.

THE Newport Iron & Steel Company, a new corporation, has bought the entire plant and property of Swift's Iron & Steel Works, and will continue the manufacture of plate, bar, angle, and boiler iron, sheet steel, and similar work.

IT is stated that the United States Rolling Stock Company has bought the car shops at Anniston, Ala., and that they will be much enlarged, making an extensive plant.

THE contract for the new Harvard bridge in Boston has been awarded by the commissioners to the Boston Bridge Company, although there were two lower bids. The amount of the bids for the superstructure of the bridge ranged from $173,700 to $210,876.

THE Schenectady Locomotive Works in Schenectady, N. Y., last year turned out 247 locomotives, an average of over 20 a month. The shops are now being enlarged by a new blacksmith shop 85 × 350 ft. in size. Arrangements will be made for lighting this shop with electric lights.

THE Baldwin Locomotive Works in Philadelphia last year built 653 locomotives, or over two a working day. This is the best record yet made, and passes that of 1882, when 563 locomotives were turned out. The number of men employed last year averaged about 3,000. Up to January 1, 1888, these works had turned out in all 8,975 locomotives.

JOHN ADT & SON in New Haven, Conn., recently finished a wire-cutting machine of a special pattern, intended to cut wires for the wire brushes of dynamos. This machine has been shipped to the Edison Electric Company at Berlin, Germany, and will be used in the shops of that company.

Marine Engineering.

THE boats used on the Pennsylvania Railroad ferry across the Hudson River at New York have all been supplied with the Williamson steam steering apparatus. This is also to be put on the ferry-boats of the Hoboken Land & Improvement Company.

A NEW steel steamship 300 ft. long and 46 ft. beam is to be built at William Cramp & Sons' yard, Philadelphia, for the Clyde line between New York and Southern ports. The new vessel will have triple-expansion engines and all the latest improvements in construction.

THE twin-screw steamer *Zizania* for the United States Lighthouse Department was launched from the yard of H. A. Ramsay & Co., Baltimore, January 17. The *Zizania* is built of steel and is a novel type of marine architecture, as she has not only twin screws, but each propeller works through a separate and independent sternpost; in fact, she is a dual ship from her dead flat extending aft, having two keels, and a single keel forward. She is 180 ft. long over all, 29 ft. beam, and 11 ft. depth of hold. Her construction is remarkable for strength, and her plating is heavy for a vessel of her class. The frames are but 18 in. apart, and the plating forward of the collision bulkhead is double. She has six absolutely water-tight bulkheads. The deck frames of lower and upper decks are of steel beams. The upper deck is plated with steel and covered with white pine. Below the main deck forward is the forecastle for the crew, and abaft the engine bulkhead in another water-tight compartment is the ward-room for the officers. The inspector's cabin and chart-room are located on the main deck, and above all is a light promenade deck extending over three-quarters of the vessel's length, where is located the pilot-house and captain's state-room. The steel plating of the hull runs up to the rail, so that her bulwarks are of steel also. In addition to her main U-shaped keel she is provided with heavy bilge keels, which will prevent violent rolling. Her rig will be that of a topsail schooner, all the standing rigging being of steel-wire rope. A steam derrick forward on the main deck is to be operated by an independent engine, and is to be used in hauling the heaviest class of buoys in and out of her hold. There are two compound engines, one to each screw; they have cylinders 15 in. and 28 in. diameter and 27-in. stroke. Both engines are finished with surface-condensing apparatus. There is one overhead return flue boiler built of Siemens-Martin steel. She has a circulating pump, steam feed and fire-pumps, and on deck are bilge and fire pumps, steam windlass, etc. All the living apartments and pilot-house are to be heated by steam, and ventilators are provided throughout.

THE new ferry-boat *Robert Garrett* for the Staten Island Rapid Transit Company was launched from the yard of the Columbian Iron Works, Baltimore, January 19. The boat has the following dimensions: Length between perpendiculars, 225 ft.; length over all, 236 ft.; breadth of beam, moulded, 36 ft.; breadth over guards, 64 ft.; depth of hull, 14 ft.; draft of water, including keel, 7 ft. 10 in.; draft of water from base line, 7 ft.; estimated displacement, 1,100 tons. The hull is of steel of 60,000 lbs. ultimate tensile strength, with a ductility of not less than 23 per cent., and an elastic limit of 35,000 lbs. The several parts are carefully proportioned, giving great strength where most needed. The plating at the water line is $\frac{5}{8}$ in. thick at the bow, tapering to $\frac{1}{2}$ in. amidships. Special attention has been paid to the strength of the bows to withstand the severe usage to which ferry-boats are subjected in entering the slips. The deck beams are of steel of the same quality. There are eight water-tight compartments in the hull, which are formed by five transverse and two longitudinal bulkheads, one of plate and angle steel, $\frac{1}{4}$ in. thick, braced with angle steel bars $3 \times 3 \times \frac{3}{8}$ in., each to have a water-tight door hung on strong hinges, and a sluice valve at keel. The longitudinal bulkheads run the length of the fire and engine-rooms and extend to the deck, stiffened by vertical angle bars 36 in. apart. The main deck is flush fore and aft, with four cabins and a central house built in the usual manner. Between the central house and the cabin on either side is a gangway. Over all comes the saloon deck, with saloon of large dimensions. It is covered in by the hurricane deck, except those portions extending over the porches of cabin below, which is left open as promenades. The engine is an inclined compound engine with cylinders 39 and 70 in. diameter and 60-in stroke. The cylinders are placed side by side and the cranks on the shaft are at right angles. The paddle-wheels are of the Morgan feathering pattern, made of unusual strength to provide against injury from ice. The boat has the Williamson steam steerer and has separate circulating, bilge, feed, and fire pumps. The two boilers are of the double-ended Scotch type, of steel, with four furnaces to each boiler. The boilers are 11 ft. 9 in. in diameter and 20 ft. long, and are intended to carry 100 lbs. working pressure.

Proceedings of Societies.

United States Naval Institute.

THE New York Branch of the United States Naval Institute held a called meeting in New York, February 9.

Captain A. P. Cooke, U. S. N., read a paper on the Naval Reserve and of the necessity for its organization, in which he discussed at length the relations of the Navy to the commercial marine, and declared that the armed ship and the armed sailor are necessities of our present civilization. The subject of Captain Cooke's paper was that the Navy should be considered as a normal school, supplying teachers to instruct and organize the seafaring population and those living along the coast, so that in case of necessity they might be prepared to undertake at once the duties which they might be called upon to assume in case of war.

The Naval Reserve should in some respects resemble the State Militia organization, but the conditions of its existence required that it should be under the control of the National and not of the State Government. He set forth at length an argument in favor of his plan, and sketched an outline for the organization for the reserve.

There was a large attendance of naval officers and of others interested in this question.

Master Car-Builders' Association.

THE following circular from M. N. Forney, Secretary, is dated New York, February 1:

"Arrangements have been made by the Executive Committee of the Master Car-Builders' Association, with the Ramapo Wheel & Foundry Company, to supply patterns of the Standard Christie Brake-Head and Shoe to members of the Association. The patterns are made of brass and are carefully finished, ready for moulding, with core boxes and lifters complete. They are intended to be used in the foundry for making castings for service, and allowance has been made for only one shrinkage.

"The prices for patterns will be as follows:

	Pattern for Brake-Head.	Pattern for Brake-Shoe.	Patterns for Brake-Head and Shoe.
For 33-in. wheels	$12.50	$7.00	$19.50
For 42-in. wheels	12.50	8 00	20.50

"These prices include boxing, f. o. b. at Ramapo. Orders should be addressed to the above-named Company at Ramapo, Rockland Co., N. Y."

American Society of Civil Engineers.

A REGULAR meeting was held at the Society's House in New York, February 1.

A paper by S. H. Chittenden, on the Work of Constructing a Dam Across the Potomac River for Increasing the Water-Supply of Washington, was read and was discussed by Messrs. Croes, Hutton, Flagg, and others.

Professor E. Muybridge, who was present as a visitor, showed some interesting specimens of his studies of the motions of men and animals by means of instantaneous photography.

The following elections were announced:

Members: Daniel Seymour Brinsmade, Birmingham, Conn.; Lorenzo Russell Clapp, Brooklyn, N. Y.; Frank Paul Davis, William Franklin Dennis, Washington; Clarence Delafield, New York; Edward Flad, St. Louis; Emil Gerber, Sioux City, Ia.; George Blagden Hazlehurst, Baltimore; Allen Bogardus Hegeman, Ottumwa, Ia.; Alexander Joseph Swift, Albany, N. Y.; Elliott H. Wilson, Butte City, Montana.

Juniors: Robert Ridgway, Sing Sing, N. Y.; Kayajiro Kobayashi, Kansas City, Mo.; George E. Moulthrop, Butte City, Montana.

A REGULAR meeting was held at the Society's House in New York, February 15.

Mr. T. C. Clarke made a statement of the results of the examination of the ceiling of the Assembly Chamber in the Capitol at Albany.

A paper by Gratz Mordecai, on the Classification of Railroad Accounts and the Analysis of Railroad Rates, was also read.

National Geographic Society.

AN Association to be known as the National Geographic Society has been incorporated in Washington. The object of this Society is to promote and increase the diffusion of geographic knowledge. The Society starts out with an enrollment of nearly 150 members.

The officers are as follows: President, Gardiner G. Hubbard; Vice-Presidents, H. G. Ogden, General A. W. Greeley, Commander J. R. Bartlett, Dr. C. H. Merriam, and Professor A. H. Thompson; Treasurer, Charles J. Bell; Recording Secretary, Henry Gannett; Corresponding Secretary, George A. Kennan; Managers, Professor J. C. Welling, Professor W. B. Powell, Captain Rogers Birney, Henry Mitchell, Marcus Baker, Cleveland Abbe, W. D. Johnson, and Professor G. Brown Goode.

The vice-presidents are to represent the several departments of geographical science. The board of managers will make arrangements for further meetings of the Society and for the general transaction of its work.

American Society of Mechanical Engineers.

THE following notice has been issued by the Secretary, Mr. F. R. Hutton, from his office, No. 280 Broadway, New York:

"Announcement is made hereby of the invitation which has been extended to the Society to hold its Spring Meeting of 1888 (XVIIth) in the city of Nashville, Tenn. This invitation has been accepted by the Council, and although the exact date has not been fixed, it will probably occur in the end of April or beginning of May, to secure the most favorable weather.

"The date of meeting coming this year earlier than usual renders it necessary for authors of papers to prepare their manuscript in early season. Several papers are promised already, but not enough to fill the docket. In arranging these details it is of great advantage to all concerned if early notice can be given of intention to contribute papers and of their titles. To secure under the approved practice of this Society the advance distribution of the papers among the members who will attend the convention, the *last* manuscripts for the meeting should be in hand before March 17, 1888.

"The Secretary will be glad to have as many of the papers as possible in print *before* that date, particularly if they are illustrated.

"Council meetings for the scrutiny of applications for membership occur at the end of February and of March. If possible, see that candidates in whom you are interested send in their applications for this meeting by the fifteenth day of those months

"It is hoped that the location selected will command an interesting and large meeting, and the duty is urged upon those members who have extended practical experience to present parts of it in brief papers, to maintain the high standard of professional excellence for which the proceedings of this Society have become so favorably known."

Master Mechanics' Association.

THE following committee circulars have been issued by Mr. Angus Sinclair, Secretary, from his office, No. 175 Dearborn Street, Chicago:

RELATIVE PROPORTIONS OF CYLINDERS AND DRIVING WHEELS TO BOILERS.

What rule do you follow in designing boilers for Passenger, Freight, and Switching Engines? To illustrate the same, please give as examples, the heating surface of fire-box and flues, also grate and flue area necessary to give best results in each of the following cases, with bituminous coal of average quality:

1. Passenger Engine; Cylinder, 18×24 in.; mean diameter of driving wheels, 61 in.; speed, 40 miles per hour; cut off at 50 per cent. of stroke.
2. Freight Engine; Cylinders, 20×26 in.; mean diameter of driving wheels, 54 in.; speed, 25 miles per hour; cut off at 60 per cent. of stroke.
3. Switching Engines; Cylinders, 18×24 in.; mean diameter of driving wheels, 49 in.; speed, 8 miles per hour; cut off at 70 per cent. of stroke.

Boiler steam pressure in all cases assumed to be 160 lbs. and 7.5 lbs. of water evaporated by each pound of coal.

CHARLES BLACKWELL,
CLEM HACKNEY,
JOHN MCGRAYEL, } Committee.

Replies should be addressed to Charles Blackwell, care Angus Sinclair, Sec. Am. Ry. Master Mechanics' Association, 175 Dearborn Street, Chicago.

PREVENTION OF DANGEROUS ESCAPE OF LIVE COALS AND SPARKS FROM ASH-PANS.

Your Committee on subject No. 7 presents for consideration the following questions, and respectfully requests that your early attention be given the matter, and that such points as, in your individual opinion, will tend to improve the appliances, and the manner of handling the same, for the Prevention of Dangerous Escape of Live Coal and Sparks from Ash-Pans, be forwarded to the address of the Chairman.

We would also ask that at the same time you forward a blue print or other drawing, of your standard ash-pans for both passenger and freight engines, showing if possible the manner of attaching to the boiler and the arrangements of dampers, grate-shakers, and damper rigging. Also give the cost complete, ready for attaching to boiler, and if patented, state the amount of royalty per engine.

1. What proportion of the fires started on the right of way, bridges, trestles, or other structures of your line, do you attribute to having originated from fire dropped from the ash-pans?
2. What kind of fuel do you use?
3. What is the length of run of your express trains? What of your through freights?
4. Have you any special rule that you require the men to observe in handling dampers and grate-shakers, and using slash bars. If so, please send copy of same.
5. As a rule, how often is it necessary to clean ash-pans on an express run? How often on a freight run?
6. Have you any appliances not yet perfected that you think will tend to lessen the danger of fire from this source? If so, please furnish us with a sketch of same.
7. Have you had any experience with the so-called dumping ash-pans? If so, will you kindly give us the results of the same?
8. Do you consider it desirable to wet the ashes that accumulate in the ash-pans? If so, please describe your manner of accomplishing the same? If not, please give your reasons?

Should you be in possession of any data or information, not covered by this circular, that you think would be of service to the Committee, will you kindly send the same with replies as above?

G. W. ETTENGER,
E. D. ANDERSON,
W. H. THOMAS. } Committee.

Answers to these questions or correspondence about them to be sent to Mr. G. W. Ettenger, Master Mechanic, Newport News & Mississippi Valley Railroad, Richmond, Va.

TENDER TRUCKS.

1. Please give a description or blue-print of your standard tender truck and state if you use center and side bearings on both trucks?

2. Do you use the same truck for passenger and freight service?

3. Do you fit up your tender trucks with any more care or labor than you do your trucks for freight cars?

4. Do you run any heavy tenders in fast passenger service, and if so, have you found it necessary to design a special truck for this service?

5. If you have, please mention any points you have found defective in your ordinary truck, and your method of overcoming such defects.

6. Do you use a dust guard for your journal boxes; and if so, describe the kind giving the best results?

7. What is the size of your standard tender journal and axle?

8. What material do you consider the best for journal bearings?

9. What diameter and kind of wheels do you use in your tender trucks for the different kinds of service, and what diameter would you recommend for fast passenger service?

10. If you use steel-tired wheels, are you troubled with flange cutting, and to what do you attribute it?

11. In using steel-tired wheels, have you found that the life of the truck is lengthened, or that it requires less repairs because of the smoother running of the steel tires? If so, can you give any data?

12. What material do you prefer for axles, and what are your reasons for the preference?

We trust that all will respond to above queries, and contribute any other information that will be valuable to Committee in compiling report on this subject.

E. M. ROBERTS,
H. D. GARRETT, } Committee.
H. D. GORDON,

Answers to this circular should be addressed to E. M. Roberts, Ashland Coal & Iron Railway Co., Ashland, Ky.

PURIFICATION OR SOFTENING OF FEED WATER FOR USE IN BOILERS.

1. Have you experimented any with chemicals for the removal or prevention of scale in locomotive boilers?

2. Have you experimented any with mechanical devices for the same purpose?

3. Have you experimented any with chemical or other devices for purifying or softening water in water tanks before delivering the water to the locomotive tank?

4. Have you succeeded in preventing the formation of scale by means of surface blow-off cock?

5. If you have used chemicals inside of the boiler successfully, with what composition have you had the best success?

6. If you have used mechanical contrivances for softening or purifying water after it has been put in the boiler, please give the name by which the device is known which you used, and notes of your experience with it?

7. If you have used chemicals or other devices for purifying the water before being delivered to the locomotive tank, please give the name by which the device is known, and, if possible, furnish a cut or something illustrating the method employed; also describe the effects produced as far as your observations go?

8. Are you of the opinion that a mechanical device can be made which will thoroughly prevent the formation of scale after the water has been put into the boiler without being first purified?

9. Are you of the opinion that some chemical agent must be used after the water has been put in the boiler without being first purified, in order to prevent the formation of scale?

10. Do you think a combination of the chemical and mechanical contrivances more desirable?

11. If you can give any information or suggestions, regarding the purification of feed water, not elicited by the foregoing queries, please send them to the Committee.

HERBERT HACKNEY,
JOHN PLAYER, } Committee.
W. T. SMALL,

Replies to be addressed to Herbert Hackney, Atchison, Topeka & Santa Fé Railroad, Topeka, Kan.

TIRES; ADVANTAGE OR OTHERWISE OF USING THICK TIRES.

There are two methods of determining the relative value of thick as compared with thin tires. One is by making tests of the density of a number of specimens of each from the same maker, to determine whether the soft core is proportionally larger in one than the other. This method is misleading, and cannot be accepted as conclusive, since it has not yet been definitely established whether the rolling friction desired may not be greater in a soft tire, nor does this method take into account the elements other than relative density which cause abrasion of the tire surface, as the frequent use of sand, slip incident to curves, slipping on grades, over-cylindered engines, etc. The other is the crucial test of daily wear, and includes all the causes which combine to wear the tire. To make a reliable comparison of these values, the Committee require tabulated information showing the mileage made during the lifetime of a series of heavy and light tires of same makes, which the Committee request you to furnish upon blanks similar to the one herewith sent you.

In addition, please state:

1. Does the use of heavy tires increase the adhesion of the engine enough to appreciably reduce the quantity of sand required?

2. What observation have you made upon the influence the engineer exerts upon the wear of tires? Can his manner of handling the engine affect the lifetime of the tires to any great degree?

3. Do you consider it advisable or otherwise, to increase the weight of the driving-wheel centers beyond the actual weight necessary for strength and durability, in order to gain adhesive power, or would it be advisable to add such weight where it would be relieved by springs?

4. Do not heavy wheel centers with thick tires produce flat spots upon the tread of tires much sooner than light wheel centers and light tires?

5. Is your road heavily graded or comparatively level, and what is the character of the traffic? As to passenger, are trains run fast with frequent stops? Also, are your freight engines rated to a high maximum of cars per train?

The name of makers and comparative value of different makes of tire will be regarded as strictly confidential between the makers of reports and the Committee.

J. W. STOKES,
C. E. SMART, } Committee.
HENRY SCHLACKS,

Address replies to J. W. Stokes, Ohio & Mississippi Railroad, Pana, Ill. This circular is accompanied by a blank form for a record of wear of tires, which master mechanics are requested to fill up.

New England Water-Works Association.

AN adjourned meeting was held at Young's Hotel, Boston, January 10, President Darling in the chair. A number of new associate members were elected.

Mr. George A. Stacey, of Malden, was the first speaker. He spoke on the question of filtering. He said that it was time that some action was taken on the question. The population is increasing, which makes the question more important, and makes it necessary to discuss the topic, because it does not seem possible always to have pure water.

The Chair informed the speaker that Professor Leeds, of Hoboken, would read a paper on filtering at the annual meeting in June.

Mr. Stearns said that many towns are already drinking filtered water. He said that the board of health had obtained good results by filtration through sand.

President Darling gave a very interesting account of a manner of filtration applicable to works that have a dam. His system had done much for the purification and the removal of sediment from water. In his filter there were 268 ft. of material, and in a new one to be built he intended to have 2,000 ft. This filters 4,000,000 gallons a day. There is one at Lewiston, Me., but that one is buried. The one at Pawtucket can be seen, and President Darling extended an invitation to all superintendents to inspect it.

Mr. Horace Holden, of Nashua, described the works in his city.

Mr. Frank Fuller discussed the recording gauge in a very interesting and instructive manner.

Mr. A. H. Howland and Mr. Brown spoke on the same subject.

It was decided to resume regular monthly meetings.

Franklin Institute.

A STATED meeting of the Franklin Institute was held at the hall of the Institute in Philadelphia, December 21, President Joseph M. Wilson in the chair.

The Council reported that 17 new members had been elected since the last meeting. Nominations were presented for officers, managers, and members of the Committee of Science and Art, to serve for the ensuing year.

Mr. George S. Strong, of New York, presented a second communication on the Strong Locomotive, describing some improvements made in the details of its construction, and gave a summary of tests made by Mr. E. D. Leavitt. The paper was referred to the Committee on Publication.

Mr. F. S. Ives gave a brief sketch on the invention of what is known as the ether-oxygen lime-light, and described several methods which had been suggested for improving this light, and also some apparatus which he had invented.

Mr. W. S. Cooper then described and exhibited specimens of some improved sanitary appliances.

The Secretary, in his monthly report, referred to the recent trials of the Westinghouse brake for freight trains, and also described portions of the new life-saving apparatus invented by Mr. J. S. Dadia, and some useful products manufactured by Mr. W. L. Lance from the waste of oil-cloth.

Resolutions providing for enlarging the building of the Institute, making more space for the library, were discussed, but not favorably received.

The nominations submitted for officers were: President, Joseph M. Wilson; Vice-President, W. P. Tatham; Secretary, William H. Wahl; Treasurer, Samuel Sartain; Auditor, Lewis S. Ware; Managers, William Sellers, Cyrus Chambers, Jr., Hugo Bilgram, G. Morgan Eldridge, Henry R. Heyl, Charles Hare Hutchinson, Samuel R. Marshall, Charles E. Ronaldson; Members of the Committee on Science and the Arts, J. M. Emanuel, C. W. Howard, Professor L. B. Hall, John Haug, Henry R. Heyl, Fred E. Ives, W. M. McAllister, Philip Pistor, H. Pemberton, Jr., Thomas Shaw, Louis H. Spellier, Professor S. P. Sadtler, T. C. Search, W. Rodman Wharton, Otto C. Wolf, Moses G. Wilder. These officers have been elected.

Railway Superintendents' Association of Memphis.

This Association has been formed by the officers of the railroads running into the city of Memphis, Tenn. Its objects, however, are not technical, but simply to regulate the relations of those roads and the interchange of traffic.

The officers of the Association are: President, M. Burke, Mississippi & Tennessee; Vice-President, R. B. Pegram, Memphis & Charleston; Secretary, A. Gordon Jones, Memphis & Little Rock.

New England Railroad Club.

The regular meeting was held in Boston, February 8, President Lauder in the chair. The subject for discussion was Wheels and Axles and their Relation to the Track.

Mr. Lobdell, of Wilmington, Del., spoke at length on chilled-iron wheels, treating the subject very thoroughly.

In the discussion following this address the merits of cast-iron wheels and the different patterns of steel-tired wheels were presented by Messrs. Adams, Laughlin, Coolbaugh, and others.

New York Railroad Club.

The regular monthly meeting was held at the rooms in New York, January 19. Mr. H. H. Westinghouse, of the Westinghouse Brake Company, gave an account of the recent tests made with that company's 50-car train.

Some general discussion on the subject of brakes for freight trains followed.

Engineers' Club of Philadelphia.

The meeting for December 17 was the decennial reception, on the tenth anniversary of the foundation of the Club. Concerning this Mr. Howard Murphy, Secretary and Treasurer, says:

"The Secretary is very glad to be able to announce to the members that both members and guests seem to have been much pleased with our little entertainment. It is almost impossible, we find, to exactly determine the number present, but it looks very much like 342. We were not, however, overcrowded, and, judging from the fragments that remained, everybody had enough to eat, —— and smoke. There was no speech-making or any attempt to introduce any feature which might have deprived the affair of an entirely informal and purely sociable character. It is believed that this entertainment will be of substantial and permanent benefit to the Club."

The tenth annual meeting was held in Philadelphia, January 14. The retiring President, Mr. Thomas M. Cleeman, read the annual address.

The Tellers reported that the following had been elected:

Active Members: Messrs. Louis H. Parke, Barton H. Coffey, Agnew T. Dice, Simon C. Long, Jacques W. Redway, Samuel Bell, Jr., George W. Chance, Charles H. Haupt, George W. Creighton, Jawood Lukens, Alan Wood, Jr., Charles R. Hall, Robert A. Cummings, T. W. Simpson, General W. F. Smith, Charles Lukens, Herbert Bamber, and Barnabas H. Bartol.

Associate Members: Messrs. George T. Mills, Michael Clarkson, and A. J. Rudderow.

The Tellers also reported that the following officers had been elected for 1888: President, Joseph M. Wilson; Vice-President, J. T. Boyd; Secretary and Treasurer, Howard Murphy; Directors, T. M. Cleeman, L. M. Haupt, Frederic Graff, Washington Jones, and Henry G. Morris.

President Wilson, on taking the chair, made some appropriate remarks.

The reports of the officers showed total expenditures of $4,111, and a balance of $586 on hand. There are now 2 honorary, 462 active, and 11 associate members.

After the business meeting, Mr. A. Marichal read a paper on the Plan Formation of Quaker Bridge Dam. The topic of his discussion was the report, by the engineers in charge, to the Aqueduct Commission, on the non-advisability of constructing the dam on a curve. This was discussed by Mr. J. E. Codman.

Mr. H. S. Prichard presented an illustrated description of a Graphical Method of Determining the Deflection of Bridges.

A regular meeting was held in Philadelphia, January 21, President Wilson in the chair.

The Secretary presented, for Mr. C. H. Ott, an account of a Peculiar Case of Transmission of Vibrations and Pulsations through Structures. Annoying, and even serious, vibrations, in this case, were found, by direct experiment, to be occasioned in a building at one end of a solid row 400 ft. long, by the operation of a small engine running a spice grinder in a retail grocery store at the other end of the row.

A general discussion of vibrations in structures followed, participated in by a large number of members, and numerous instances were noted.

Professor L. M. Haupt submitted a few extracts from the Report of the Chief of Engineers with reference to the Theoretical Operation of Submerged Jetties, and made some comments thereon to show why the system had apparently not proven more successful.

Mr. A. Marichal presented a mathematical discussion of the Theory of Curved Dams for the *Reference Book.*

Mr. F. W. Whiting noted a case in hydraulics, where attempt had been made to bring water in a pipe across an embankment, which had been unsuccessful until an opening was made at a point in the pipe line, and a small pipe extended therefrom to the level of the source.

Mr. Howard Murphy suggested that the trouble had probably been caused because the hydraulic gradient had not been considered in the original location of the main pipe.

A regular meeting was held February 4. Professor Haupt submitted, with explanations, a bill now before Congress providing for the establishment of a Bureau of Harbors and Rivers, to be officered by a separate corps of civil engineers.

The Society adopted resolutions recommending the use of rain-gauges by the United States Signal Service.

Mr. A. Marichal read a paper on Rainfall, accompanied by diagrams and observations.

Resolutions relating to the publication of papers were, after discussion, referred to the Publication Committee.

A resolution that the Club adopt the 24-hour time system was postponed to the next business meeting.

Connecticut Association of Civil Engineers and Surveyors.

The annual meeting was held in Hartford, January 10, President C. E. Chandler in the chair. The Secretary's report was read by D. S. Brinsmade, of Birmingham. The members of the Association, honorary, contributing, and active, number 89. The increase in membership, the sound financial basis, afforded in the mind of the Secretary good reason for congratulation.

He did not think the time was far distant when their increased facilities would allow a room of their own, with a library and other attractions.

President Chandler summed up the Association's prosperity in a brief address. He greatly urged the engineers to write. He said all had something to do, and could write about it. He added that all could systematize their work to this end.

Some business was done before the close of the first day's session, and these officers were chosen: President, C. H. Bunce, of Hartford; First Vice-President, E. F. Weld, of Waterbury; Second Vice-President, William B. Palmer, of Bridgeport; Secretary and Treasurer, D. S. Brinsmade, of Birmingham; Assistant Secretary, E. P. Augur, of Middletown. The Committee on Nominations brought in the following, who were elected: Executive Committee, C. Chandler, of Norwich; B. H. Hull, of Bridgeport; E. P. Augur, of Middletown; C. M. Jarvis, of Berlin; C. H. Bunce, of Hartford. Membership Committee, T. H. McKenzie, of Southington; H. G. Loomis, of Hartford; W. B. Palmer, of Bridgeport.

On the second day papers were read by E. P. Augur on the Adjustable Effluent Pipe of the Middletown Reservoir; by F. B. Durfey on the New Water Works at Bath, Me.; by F. W. Whitlock on Co-ordinate Surveying and Plotting, and by T. H. McKenzie on Mason Work.

The paper on Mason Work called out a long discussion, and there was also a discussion on the Rental Value of Hydrant Service.

Boston Society of Civil Engineers.

A REGULAR meeting of this Society was held December 21, 24 members and 3 visitors present.

Mr. Charles E. C. Breck was elected a member, and four names were proposed for membership.

A vote of thanks was tendered Mr. A. V. Abbott for the interesting description given at the last meeting of the superheated water system of Boston.

The government of the Society was authorized to make any arrangements it deemed advisable in relation to the coming meeting at Boston of the American Institute of Mining Engineers.

The Secretary read a paper prepared by George A. Ellis giving a description of the Racine Water Works.

Mr. M. M. Tidd occupied the rest of the evening, speaking in an informal way of the construction of dry docks.

A REGULAR meeting was held in Boston, January 18, President Rice in the chair; 31 members and 8 visitors present.

Messrs. Otis F. Clapp, Isaac K. Harris, D. W. Pratt, and Waterman Stone were elected members.

A communication was read from the Kansas Association of Engineers in relation to the interchange of papers. The President was authorized to reply to this communication in behalf of the Society.

The President announced the appointment by the Government of the following committee to extend courtesies to the American Institute of Mining Engineers at its coming meeting in Boston: H. L. F. Rice, William Jackson, Seth Perkins, Thomas J. Young, and W. S. Chaplin.

Mr. Jerome Sondericker read a paper on an Investigation as to how to Test the Strength of Cements. The paper was discussed by Messrs. Allen, Clarke, Lanza, Rice, Smith, and Stearns.

Engineers' Club of Kansas City.

THE first annual meeting was held at the Club's rooms in Kansas City, December 19. Reports of the Executive Committee, Secretary, Treasurer, and Librarian were read and approved. It was voted that for the ensuing year the offices of Secretary, Treasurer, and Librarian be united.

Nominations for officers were made, as follows: For President, William B. Knight, J. A. L. Waddell; for Vice-President, O. Chanute, A. J. Mason; for Secretary, Treasurer, and Librarian, Kenneth Allen, W. H. Breithaupt; for directors, T. F. Wynne, W. Kiersted, William B. Knight, W. H. Breithaupt.

Mr. Waddell read selections from his General Specifications for Highway Bridges of Iron and Steel, and requested that the Club endorse the objects of the paper.

On motion of Mr. Kiersted it was voted that the President appoint a committee of three members of the Club to consider the advisability of such action. Those appointed were Messrs. Chanute, Breithaupt, and Mason.

After a few remarks by Mr. Walker, of Cleveland, the Club adjourned.

At the meeting of January 9 the officers named above were elected. This meeting was followed by the annual supper.

A REGULAR meeting was held in Kansas City, February 6. Mr. A. Lasley, A. W. Boeke, and F. L. Mills were elected members. Mr. J. A. L. Waddell was declared elected Treasurer.

The committee appointed to consider Mr. Waddell's pamphlet on Highway Bridges presented their report. It was resolved to devote the regular meeting in April to the discussion of this subject.

Mr. B. L. Marsteller read a paper on Inspection of Iron Bridges and Viaducts. This was discussed by several of the members present.

Engineers' Club of St. Louis.

THE Club met in St. Louis, December 21, President Potter in the chair, 30 members and 2 visitors present. The Executive Committee announced the result of the ballot for officers as follows: President, M. L. Holman; Vice-President, J. A. Ockerson; Librarian, J. B. Johnson; Secretary, William H. Bryan; Treasurer, Charles W. Melcher; Directors, William B. Potter and F. E. Nipher.

The chair announced the election of the new officers, thanked the members for their co-operation in furthering the interests of the Club, and then appointed Messrs. Ockerson and Gale a committee to escort the new President to the chair. On taking his seat, Mr. Holman thanked the Club for the honor conferred upon him, and promised to perform his duties to the best of his ability. He then called upon the retiring President for some remarks appropriate to the occasion. Professor Potter addressed the Club on the present status of the profession and of the Engineers' Club of St. Louis in particular. His remarks were largely historical, and he suggested the appropriateness of celebrating the twentieth anniversary of the Club's formation, on November 4, 1888, by a social reunion of some kind. A printed catalogue of the Club's literature was suggested. The benefits resulting from the Association of Engineering Societies and the *Journal*, with its index department, were referred to. While a closer union of engineering societies might not yet appear desirable, he pointed out a number of ways in which co-operation might result in benefit to all. The question was commended to the thoughtful consideration of the Club.

The following amendment having been duly announced was then adopted unanimously:

"*Resolved*, That Section 2 of the by-laws be amended, by inserting after the words, 'and for non-resident members $4,' the following: 'Members elected after the last meeting in June shall have the option of paying $4 for the current year and receive the *Journal*, or $1 without the *Journal*.' "

On motion the Executive Committee was instructed to remit such part of the dues already charged to members elected since June last, as will give them the benefit of the amendment just adopted.

The Secretary then read a paper by Mr. Isaac A. Smith on Rapid Railroad Embankment Construction, being an account of the construction of an embankment in North St. Louis containing 97,500 cubic yards, within a period of 16 days. The material was river silt, and the cost 18.58 cents per cubic yard —but little more than half of the lowest bid received from contractors, none of whom would give a time guarantee. Messrs. Bryan and Wheeler took part in the discussion, in which it was shown that the shrinkage six months after was 11 per cent.

A vote of thanks was given Professor Potter for his address, which was ordered published. The address was discussed by Professor Johnson, Messrs. J. A. Seddon, Flad, and Holman.

Papers by Charles H. Ledlie and Professor Charles C. Brown were announced for the next meeting, January 4, 1888. Professor Engler called attention to an ingenious model of the hyperboloid of revolution.

A REGULAR meeting was held in St. Louis January 4, President Holman in the chair. Messrs. Robert H. McMath, J. W. Schaub, James M. Sherman, A. W. Hubbard, and Joseph F. Potter were elected members.

The paper by Mr. Charles H. Ledlie, entitled Construction of Dam and Reservoir at Athens, Ga., was then read by Professor Johnson. The method of carrying out the work was given in detail and sketches of the principal features were submitted. The protection of this kind of work against crawfish and musk-rats was shown to be of prime importance. Messrs. Moore, Holman, Johnson, and Flad took part in the discussion.

Professor Nipher then read a paper on The Volt, the Ohm, the Ampere—What Are They? being a mathematical discussion

of the subject. The results were shown and their value to the electrical engineer explained. The paper was illustrated by suitable apparatus and drawings. Messrs. Holman, Flad, Moore, and Seddon participated in the discussion.

A REGULAR meeting was held in St. Louis, January 18. Malverd A. Howe was elected a member.

The Secretary read a communication from the Civil Engineers' Association of Kansas on the subject of Interchange of Papers and Proceedings.

Professor Johnson called attention to a pamphlet by J. A. L. Waddell on the subject of Improvements in the Construction of Highway Bridges. It was ordered that a committee of three be appointed to consider same with a view to endorsing the author's ideas. The chair appointed as such committee J. B. Johnson, Robert Moore, and N. W. Eayrs.

Mr. N. W. Eayrs then read a paper on the Improvement of Nantucket Harbor, Mass.

The Secretary read a paper by Professor C. C. Brown, of Union College, Schenectady, N. Y., on State Surveys.

Professor Nipher exhibited another specimen of cast iron cap burst by hydraulic pressure caused by firing a rifle ball into a cylinder of water, the bottom of which was closed by the cap.

Mr. Crow exhibited an improved form of radial draw-bar as adapted for cable car service.

AT the meeting of February 1 the committee appointed to recommend suitable action on Mr. Waddell's efforts to reform present practice in the building of highway bridges reported as follows:

"*Resolved*, That this Club express their approval of the pamphlet entitled 'General Specifications for Highway Bridges of Iron and Steel,' by J. A. L. Waddell, and deem it a well-considered effort to bring about a much-needed reform.

"That we recommend these specifications to the consideration of county and town boards as calculated to give structures both safe and economical when faithfully carried out, but that to insure these results competent engineering supervision is absolutely necessary.

"That in the letting of highway bridge contracts and in the acceptance of the finished structures such boards should, in all cases, call to their aid a competent civil engineer, and thus insure at once the public safety and the wise expenditure of the public funds."

J. B. JOHNSON,
ROBERT MOORE, } Committee.
N. W. EAYRS,

The report was accepted and after discussion was laid on the table with notice that it would be called up in two weeks.

Resolutions were adopted recommending that the Signal Service stations be supplied with self-registering rain-gauges.

Mr. Carl Gayler then read a paper on Highway Bridge Floors, giving several standard designs, with their weights and cost.

Mr. B. F. Crow read a paper on Constructive Accounts, showing how the cost of the material and labor required to produce each integral part of a street car is found, by means of labor and material accounts with all the orders. Both papers were discussed.

Minneapolis Society of Civil Engineers.

THE following officers have been elected for the ensuing year: President, W. A. Pike; Vice-President, E. B. Abbott; Secretary, Walter S. Pardee; Treasurer and Assistant Secretary, B. O. Huntress; Librarian, W. W. Redfield; Member of Board of the Association of Engineering Societies, Andrew Rinker; Membership Committee, Andrew Rinker, M. D. Rhame, and R. A. Sanford; Entertainment Committee, George W. Sturtevant and F. W. Chappelon; House Committee, W. W. Redfield and S. C. Deverly.

Illinois Society of Engineers and Surveyors.

THE third annual meeting was held in Springfield, Ill., January 25, 26, and 27. Three sessions each day were held, and the attendance throughout was large. The reports of the several officers and committees were submitted and acted upon, and numerous interesting papers were read by different members of the Society.

Senator Cullom's bill establishing a Bureau of Public Works was approved.

On Thursday, January 26, the Society went on special train on the Wabash Railway, by invitation of Charles Hansel, Chief Engineer, to the rolling mills and other points of interest.

A feature of the meeting was the exhibition of drawings, which was large, varied, and interesting. Thirty new members were elected, and the following officers were chosen for 1888: President, C. G. Elliott, Gilman; Vice-President, D. W. Mead, Rockford; Executive Secretary, Professor A. N. Talbot, Champaign; Recording Secretary, S. A. Bullard, Springfield; Treasurer, A. N. Talbot, Champaign; Executive Board, A. H. Bell, A. N. Talbot, E. A. Hill, G. P. Ela, C. G. Elliott.

The next meeting will be held in Bloomington, Ill.

Montana Society of Engineers.

THE annual meeting of this Society was held at Helena, Montana, January 21. The usual routine business was transacted and the meeting was followed by a banquet.

The following officers were elected for the ensuing year: President, George K. Reeder; Vice-Presidents, E. H. Wilson and E. A. Beckler; Treasurer, J. W. Wade; Secretary and Librarian, J. S. Keerl.

Indiana Society of Civil Engineers and Surveyors.

THE eighth annual meeting of the Indiana Society of Civil Engineers and Surveyors was held in Indianapolis, January 17, 18, and 19. The papers and reports submitted at this meeting were Drainage, by L. S. Alter; Topography, by Professor Phillips; the Relation of Astronomy to Surveying, by Professor C. A. Hargrave; Construction of Railroads and Bridges, by M. S. Fries; A New Transit and Wye-Level, by L. Beekman. There were discussions on several of these papers and also on other topics brought before the Society.

It was decided to hold the next meeting in Indianapolis, December 11, 1888.

The following officers were elected: President, J. C. Pulse, Greensburg; Vice-President, E. B. Vawter, Lafayette; Recording Secretary, J. E. Brown, Frankfort; Corresponding Secretary, G. M. Cheney, Logansport; Treasurer, R. L. Morrison, Knightstown.

Ohio Society of Surveyors and Civil Engineers.

THE ninth annual meeting was held in Columbus, O., January 10, 11, and 12, the attendance being larger than at any previous meeting. Twenty new members were elected.

On the first day the following papers were read: The Judicial Functions of the Surveyor, by Homer White; Adverse Possession, by E D. Haselton; Steel Tapes as Standards, Professor J. B. Johnson; an address by George R. Gyger, on Protection from Incompetency, and a historical sketch of Our Public Domain, by J. T. Bruck.

The evening exercises were opened by the address of President W. H. Jennings. Dr. Edward Orton, of Ohio State University, gave a lecture on Road-making Materials of the State. Mr. C. A. Hanlon presented a paper on State Topographical Survey. The evening closed with a report of the Committee on Civil Engineering.

The afternoon of the second day was largely spent in discussing the material used in paving of streets and making of roads. A free exchange of opinion as to the merits of certain paving stones was made and considerable attention paid the manner of laying them.

A committee from the Centennial Commission, who waited upon the Society for the purpose of having a display of relics of the profession 100 years ago, at the coming centennial, was informed that their request would be complied with so far as was possible. The following papers were read during the day: Jonathan Arnett, on Philosophy of Underdrainage; Frank Kennedy, on the Catfish System of Drainage; G. S. Innis, on Construction of Turnpikes; Notes on Paving, by Thomas R. Wickenden; Cleveland City Pavements, by M. E. Rawson; Street-Crossings and Sidewalks, by R. A. Bryan; Street Grades and Records, by W. H. Jennings; Construction, Maintenance, and Repairs of Short-span Highway Bridges, by S. A. Buchanan; Computation of Strains in Highway Bridges, by Professor C. N. Brown; H. T. Lewis, on Bridge Details; Lifting and Moving of Bridges, by Thomas H. Johnson; Pile Foundations, by Julian Griggs; Masonry as Applied to Railroad Work, by A. G.

Pugh ; Puzzles for the Enquirer, by W. A. Gain ; Comparative Cost and Efficiency of Tile Drain and Open Ditches, by E. O. Opdycke ; Street Grades and Monuments, by C. S. Lee ; Monumenting, by F. Hodgman.

On the morning of the last day the reports of the retiring officers were submitted and approved, and papers were read and discussed by W. C. Rowe on the Circleville Water-works ; by B. F. Bowen, on Mortar, and by William Reeder, on the Difficulties of Surveying in the Virginia Military District.

A petition signed by W. H. Jennings, Chief Engineer of the Hocking Valley Railroad, and nine other Columbus engineers, asking for permission to form a local association, was favorably acted upon. The Committee on Legislation reported in favor of abandoning the worthless portion of the Ohio Canal, but no action was taken on the report other than its acceptance.

The matter of an exhibit during the Centennial in Columbus in September was referred to the local members of the Association with power to act. The Committee on Legislation was instructed to formulate a bill to govern the qualifications of persons acting as civil engineers in this State, for presentation at the next annual meeting.

At the afternoon session J. N. Bradford, of Ohio State University, gave an illustrated lecture on Duplication of Blue Prints, and Mr. Cully read a paper on Landscape Engineering

The following officers were elected : President, J. D. Varney, Cleveland ; Vice-President, O. B. Opdycke, Bryan ; Secretary, C. N. Brown, Columbus ; Treasurer, F. G. Sager, Columbus ; Trustees, W. H. Jennings, Columbus ; T. R. Wickenden, Toledo ; F. M. Davidson, West Manchester ; C. A. Judson, Sandusky ; William Reeder, London.

Western Society of Engineers.

The annual meeting was held in Chicago, January 3. The reports of the retiring officers were presented, and the following officers elected for the ensuing year are : President, A. Gottlieb ; Vice-Presidents, John W. Weston, O. Chanute ; Secretary, L. E. Cooley ; Treasurer, W. S. Bates ; Librarian, G. A. M. Liljencrantz ; Trustee, O. B. Green.

The meeting was followed by the annual banquet, in which some 50 members participated, which was also made the occasion of a presentation from the Society to Mr. L. P. Morehouse, who for 18 years has been Secretary. The testimonial was a copy of the *Encyclopedia Britannica* in 24 volumes.

Civil Engineers' Society of St. Paul.

The annual meeting was held in St. Paul, Minn., January 10. A paper was read by M. A. Munster upon Formula for Calculation of Plate-girders. A. Johnson, United States Assistant Engineer, read a paper on the Preservation of the Falls of St. Anthony, at Minneapolis, citing the work of 1883 done under the direction of Major C. J. Allen.

The following officers were elected for the ensuing year : President, C. F. Lowett ; Vice-President, J. H. Morrison ; Treasurer, J. C. L. Annan ; Secretary, George L. Wilson ; Librarian, A. Munster.

Civil Engineers' Association of Kansas.

The adjourned annual meeting was held in Wichita, Kan., December 3. The following officers were elected for the ensuing year : President, Jerome C. Herring ; Secretary, H. H. Hendershot ; Librarian, R. W. Luttrell ; Treasurer, H. H. Jackman ; Executive Committee, R. H. Brown and W. R. Kessler. Twelve new members were elected and several applications received and referred.

A regular meeting was held in Wichita, January 17. Three new members were elected. A number of communications were presented and acted on.

The Secretary was instructed to correspond with societies of like character with a view of identifying the interests and an interchange of proceedings.

Engineers' Society of Western Pennsylvania.

At the annual meeting in Pittsburgh the following officers were elected for 1888 : President, Alexander Dempster ; Vice-President (two years), W. L. Scaife ; Directors, T. P. Roberts, Charles Davis ; Secretary, S. M. Wickersham ; Treasurer, A. E. Frost.

OBITUARY.

Benjamin F. Crane, who died in New York January 18, aged 71 years, was a civil engineer of long standing, and well known among the older members of the profession. He was born in Saratoga, N. Y., and served as assistant or resident engineer on the Erie Canal, the Croton Aqueduct, and the New York Central Railroad. He was the first Superintendent of the Central Park, New York City.

John A. Bailey, for many years Engineer of the Lighthouse Department, died in Marquette, Mich., January 22, aged 69 years. He entered the service of the Government in 1856, and had charge of the construction of many lighthouses along the Atlantic coast. He superintended laying the cable from Florida to Cuba ; erected Spectacle Reef Light, in Lake Huron, in 1871. The last public work which he completed was the building of St. Annan Rock Light in Lake Superior. At the time of his death he was superintending the erection of the buildings of the Michigan Branch State prison at Marquette.

Richard Emerson Butterworth, who died in Grand Rapids, Mich., January 17, aged 81 years, was born in Jamaica, West Indies. He was educated in England, and choosing the profession of an engineer, placed himself under the tuition of William Nicholson, of Manchester. He recalled the construction in 1830 of George Stephenson's locomotive, the *Rocket*, and was one of the party which rode upon it on its trial trip. For several years he was engaged at Manchester in the manufacture of cotton, but later settled in the United States. In 1875 he made the pumping-engines and machinery for the Grand Rapids water-works, and was also identified with similar undertakings in different parts of the country.

George H. Corliss, the well-known manufacturer and mechanical engineer, died in Providence, R. I., February 21, of gastric fever, after a short illness. He was 71 years old. Mr. Corliss was born in Easton, N. Y., in 1817, and did not take up the profession in which he attained eminence until he was 25 years old. He went to Providence in 1844, in 1846 began the development of his steam-engine improvements, and in 1848 completed an engine which embodied the essential features of the present Corliss engine. Mr. Corliss had won a large number of medals and had many honors conferred upon him He carried away the highest competitive prize at the Paris Exhibition in 1867 ; was presented the Rumford Medals in 1870, the late Dr. Asa Gray, President of the Academy, making the presentation, and won the grand diploma at the Vienna Exhibition in 1873. Mr. Corliss was a Commissioner for Rhode Island at the Centennial Exhibition, and was one of the Executive Committee of seven that was intrusted with the preliminary work. His engine for transmitting the power all over Machinery Hall added to his fame. The undertaking cost him $100,000, and is the most princely gift ever given by an individual to such an exhibition. He was actively interested in public affairs, but the only offices he ever held were those of State Senator and Presidential Elector. The Corliss Engine, which is known all over the world established Mr. Corliss's fame, and it is through that engine that he will be remembered. He was, however, also very successful as the organizer and manager of a great manufacturing establishment.

Professor Asa Gray, of Harvard University, died at his residence in Cambridge, Mass., January 30. He was born in Paris, N. Y., in 1810, and was graduated from Fairfield Medical College when he was 21, but soon left the practice of his profession for the field of botany. In 1836 he published his "Elements of Botany." When the University of Michigan was organized in 1838, he had already acquired such reputation as to cause his appointment to be Professor of Botany and Zoölogy. He took hold with a will, and got together a library of 4,000 volumes, having started the chair very well when in 1842 he was chosen Fisher Professor of Natural History at Harvard College, which position he retained until his death. The revolution in botany within his time, in which he has been one of the most able and important factors, has been entire ; the artificial systems of Linnæus, De Candolle, and others (which were of great use in their day) had to give way to the natural methods which the exact observation of modern science demanded ; and in this Gray was a leader. With Dr. John Torrey, who was his old teacher in medicine, he had begun in 1838 the great work, "The Flora of North America," which they carried together to the completion of the great order Compositæ. Dr. Torrey gave it up at this point, but Professor Gray

has continued to work upon it. He also published many other works on botany, besides delivering lectures, and published several works on the Darwinian theory of evolution. From 1863 to 1873 he was President of the American Academy of Arts and Sciences; and he was a member of most of the scientific societies of this country and a corresponding and honorary member of many abroad. He has not taught actively since 1873, but devoted himself to the charge of the herbarium and to scientific work. In 1874 he was appointed successor of Agassiz as a regent of the Smithsonian Institute at Washington. Professor Gray was widely esteemed, not only for his scientific attainments, but for his personal qualities.

PERSONALS.

J. R. GROVES has been appointed Superintendent of Rolling Stock of the St. Louis & San Francisco Railroad, with office at Springfield, Mo.

F. W. GERECKE is now Chief Engineer in charge of the Chicago Water-works. He is an engineer of much experience in that line.

GEORGE T. JARVIS, recently on the Mexican Central, has been appointed Superintendent of the Duluth, South Shore & Atlantic Railroad.

JOHN HERRON has been appointed Principal Assistant Engineer of the Montana Central Railroad, with office in Helena, Montana.

MAJOR CHARLES W. RAYMOND, U. S. Engineer, has been detailed to duty as Engineer Commissioner of the District of Columbia, replacing MAJOR WILLIAM LUDLOW, who is ordered to other duty.

OSCAR SANNE, late with the Dominion Bridge Company, is now Assistant Engineer of Bridges and Buildings of the Chicago, Milwaukee & St. Paul Railway.

J. F. O'ROURKE, of New York, has charge of the building of the foundations and piers of the new bridge over the Rio Grande at Laredo, Tex., for the Mexican National Railroad.

H. TANDY, recently of the Brooks Locomotive Works and formerly on the Grand Trunk road, has been appointed Superintendent of Motive Power of the New York, Ontario & Western Railroad.

T. J. NICHOLL, an engineer of long experience in railroad work, is now General Manager of the Natchez, Jackson & Columbus Railroad; his headquarters are at Natchez, Miss. The company proposes doing much new construction work during the present year.

PEYTON RANDOLPH succeeds Mr. E. B. Thomas as General Manager of the Richmond & Danville Railroad and its controlled lines. Mr. Randolph has been connected with the company for several years as Engineer, Superintendent, and Assistant General Manager.

E. B. THOMAS has been elected Second Vice-President of the New York, Lake Erie & Western Company, and will have especial charge of that company's New York, Pennsylvania & Ohio and Chicago & Atlantic lines. Mr. Thomas was formerly General Manager of the Cleveland, Columbus, Cincinnati & Indianapolis road, but has been for some time past Vice-President and General Manager of the Richmond & Danville.

CHARLES BLACKWELL, formerly with the Norfolk & Western, later on the Union Pacific, and for some time Manager of the Montana Union road, has been appointed Engineer of the Machinery Department of the Central Railroad of Georgia, with office in Savannah, Ga. Mr. Blackwell is well known as a mechanical engineer, and is an active and valued member of the Master Mechanics' and the Master Car-Builders' Associations.

COLONEL MARSHALL McDONALD, who has been appointed United States Commissioner of Fisheries under the new law establishing the office as a distinct department, was for a number of years Professor in the Virginia Military Institute. In 1879 he was appointed Assistant to the late Professor Baird, and has since done much valuable work in connection with American fisheries.

JOHN W. FERGUSON, for 10 years past Assistant Engineer on the New York, Lake Erie & Western Railroad, has resigned his position to accept an engagement with the firm of Bernard Kelly & Sons, bridge and dock builders, of New York City. Mr. Ferguson will remain with the Erie a short time to complete the work of building a new draw-bridge over the Hackensack River, upon which he has been engaged for some time.

THE copartnership of WILSON BROTHERS & Co., of Philadelphia, civil engineers and architects, has expired. The old business will be settled by John A. Wilson and Joseph M. Wilson, and a new copartnership has been formed under the old firm name for the transaction of a general business as civil and hydraulic engineers and architects, by JOHN A. WILSON, JOSEPH M. WILSON, HENRY W. WILSON, CHARLES G. DARRACH, and HENRY A. MACOMB. The office is at 435 Chestnut Street, Philadelphia.

NOTES AND NEWS.

Mediæval and Modern Armor.— . . . . . In the middle of the seventeenth century armor had had its day.

And it has had its analogies. Have not we, in the last 25 years, repeated in another field three centuries of experiments? Were not the light cruisers of Drake and Hawkins circling about the huge Spanish galleons a foretaste of what may yet be to come?

When the *Merrimac* steamed down into Hampton Roads, crushing the *Congress* and the *Cumberland*, it was the barded knight destroying those lighter armed: and since then, in the armoring of ships, improvement has followed improvement.

In the old times the individual shut himself up in a shell, which he thickened and strengthened to resist projectiles, till, condemned to be immovable or risk the chances of bullets, he cast away his armor.

To-day instead of one, we shut up many in a floating iron shell. Every year sees a heavier gun and a heavier target. Again it is the costly knight whom a single shot sends down with all his wealth of armor. Shall we not, too, perhaps, with our great ships of war, cast off, as did the knight, first the greave and soleret that impeded the feet, then another and another piece of iron, till to the 140-ton gun we oppose only speed and activity?

If so, we shall have repeated the experience of the middle ages. The knights of Cressy and Agincourt will stand to us not merely as entertaining historical figures, but as teachers; and the faint echo of the splintering lances of the crusaders will come to us charged with a lesson.—*From "The Man-at-Arms," in Scribner's Magazine for February.*

American Pig Iron Production.—The *Bulletin* of the American Iron & Steel Association says: "The total production of pig iron in this country since 1880 has been as follows:

Years.	Gross Tons.	Years.	Gross Tons.
1880	3,835,191	1884	4,097,868
1881	4,144,254	1885	4,044,526
1882	4,623,323	1886	5,683,329
1883	4,595,510	1887	6,417,148

"Our production of pig iron in 1887, classified according to the fuel used, was as follows, in net tons, compared with the production in 1885 and 1886.

Fuel Used.	1885.	1886.	1887.
Bituminous	2,675,635	3,806,174	4,270,635
Anthracite	1,454,390	2,099,597	2,338,389
Charcoal	399,844	459,557	578,182

"The anthracite figures include all pig iron made with mixed anthracite and coke, as well as that made with anthracite alone. . . . . .

"Our production of spiegeleisen in 1887, included in the figures already given of the total production of pig iron in that year, was almost exactly the same as in 1886. In 1886 it amounted to 47,982 net tons, and in 1887 to 47,598 net tons.

"The stocks of pig iron which were unsold in the hands of manufacturers or their agents at the close of 1887, and which were not intended for the consumption of the manufacturers, amounted to 337,617 net tons, against 264,717 net tons on June 30, 1887, and 252,704 net tons on December 31, 1886. In addition to unsold stocks in the hands of manufacturers at the close of 1887 there were also about 28,000 net tons of unsold pig iron in the hands of various other parties in Virginia, Pennsylvania, Alabama, Tennessee, and Michigan."

The Merced Irrigation Canal.—The opening of this California canal was recently celebrated at the reservoir near Merced, Cal., which has been named **Lake Yosemite.** This canal, which has been several years under construction and has cost $1,500,000, is 27 miles long, 100 ft. wide at the top, 70 ft. at the bottom, and 10 ft. deep. It will irrigate 300,000 acres of fertile land. It receives an inexhaustible supply of water from the Merced River flowing through the Yosemite Valley which is supplied by the snows of the Sierras. At a point two miles below the falls at Merced a dam raises the stream 10 ft. above its normal level. The great engineering features of the work are two tunnels, one 4,400 ft. long, driven through solid rock,

no supports being necessary; the other, 3,000 ft. long, faced with timbers. The dam across the small valley near Merced, constructed to form a reservoir, is 4,000 ft. long, 275 ft. wide, and 54 ft. high. The level of the reservoir is 90 ft. above Merced. Water will be conveyed there in large pipes. It is believed the fall will be sufficient to run by water power flour mills and other manufacturing enterprises. Colonies will be settled along the line of the canal, which is the most important enterprise of a similar character ever carried to a successful termination in California.

Brick and Stone Bridges of Large Span.—Professor E. Dietrich, of Berlin, enumerates 57 bridges of brick or stone existing which have a span greater than 130 ft., and says that there are no others over that size. Of these bridges 33 are highway and 22 railroad bridges, one carries a canal, and one an aqueduct. Of the 57 there are 27 in France, 13 in Italy, 10 in England, two each in Austria and Spain, and one each in Germany, Switzerland, and the United States. The American bridge has the largest span of all—it is the Cabin John Bridge near Washington, which is a single arch of 237 ft. span. Of the 57 bridges only three others are over 200 ft. span; 10 are between 164 and 200 ft., and 43 between 131 and 164 ft. Fourteen of them were built before 1800; 22 between 1800 and 1860; 5 between 1860 and 1870; 6 between 1870 and 1880, and the remaining 10 since 1880.

In 22 of these bridges the rise is between one-third and one-half the span; in 18 between one-third and one-fourth; in 10 between one-fourth and one-fifth, and in six between one-fifth and one-eighth. One bridge, in Turin, Italy, has a still flatter arch, the rise being in the proportion of 1 : 8.18 to the span.

Baltimore & Ohio Employes' Relief Association.—The November sheet of this Association shows payments of benefits to members as follows:

	Number.	Amount.
Accidental deaths	4	$3,500
Accidental injuries	337	5,040
Natural deaths	13	5,300
Sickness	549	8,566
Physicians' bills	186	1,676
Total	1,089	$24,082

The Association had paid out in benefits up to November 30 last the sum of $1,563,167 in all.

Accidents on Indian Railroads.—The *Indian Engineer* says: "The returns of accidents on Indian railroads during the first quarter of the year 1887 show that on an open mileage of 13,002 miles, with a train mileage of 11,765.517 miles, the total number of persons killed was 83, and of those injured 185. Of the number killed, however, 41 deaths occurred among persons unconnected with the railroads either as passengers or as servants, of which 4 were due to accidents at level-crossings, 34 due to persons trespassing on the lines and persons committing suicide, and 3 to unexplained causes; while of the total number of persons injured, 16 were unconnected with the railroads, and received their injuries either through passing over level-crossings when trains were running, or from trespassing on the line.

"It is satisfactory to note that not a single passenger was killed, during the quarter, in a railroad accident, though 10 met their deaths through their own misconduct or want of caution, from falling when getting in or out of trains, falling out of carriages when trains were in motion, etc., and 11 injured through similar acts of carelessness or want of caution. In accidents proper, 47 passengers received injuries, 37 of whom were injured by collisions, 8 through trains or parts of trains leaving the rails, and 2 owing to accidents caused by obstructions on the lines. Accidents were more fatal to railroad servants than to passengers, 32 of the former having been killed during the quarter and 113 injured. The large majority of deaths (27 out of the 32) are, however, said to be due to misconduct or want of caution on the part of the persons killed; while of the total number injured (113), no less than 103 have, according to the report, nothing to blame but their own carelessness for the injuries they have received."

A New British Cruiser.—The new steel twin-screw armored cruiser *Galatea*, which has been built and engined by Messrs. R. Napier & Sons, of Glasgow, has now completed her trial trips under both natural and forced draft. As first designed the *Galatea* and her sister ship, the *Australia*, were intended to have ordinary compound engines, but owing to the representations of Messrs. Napier, the Admiralty finally permitted engines of the triple-expansion type to be substituted, a change which has resulted in obtaining a speed of rather more than a knot in excess of that originally expected, while the weight of the machinery has not been increased. The natural draft trials were made in the Solent on November 9, when an average of 5,858 H.P. was indicated during the four hours' run, and a speed of 17.397 knots was obtained. The boilers steamed freely, an average pressure of 129.8 lbs. being maintained throughout the trial; the engines made an average of 101.15 revolutions per minute, and the mean vacuum was 27.5 in. The forced draft trials took place November 11 under the superintendence of Mr. A. C. Kirk, the senior partner of Messrs. Napier & Sons. They commenced with a series of tests of the circle-turning qualities of the ship at full speed, and very satisfactory results were obtained. On the completion of these tests the trial proper was proceeded with, a series of runs being made on the measured mile in Stokes Bay, when a mean speed of 19.008 knots was obtained with an average of 9,205 indicated H.P. The mean pressure of steam in the boilers was 138 lbs., the vacuum 27.16 in., and the revolutions 113.5 per minute. Steam was blowing off throughout the trial, though the air pressure was only 1 in. on the water-gauge. The engines ran very smoothly, and no water was used on the bearings. The runs were made on a mean draft of 21 ft., which is what the *Galatea* will draw when completely equipped. During part of the run the engines indicated 9,664.5 H.P., and the mean for the last three hours was 9,414.10 indicated H.P. The machinery has been designed to work with maximum efficiency when at full power, and with forced draft, and under these conditions the coal consumption was 1.97 lbs. per indicated H.P. per hour; under natural draft 2.3 lbs. per indicated H.P. per hour were consumed. The weight of the machinery was only 770 tons, or 1.67 cwt. per indicated H.P.—*London Engineering*.

Indian Frontier Railroads.—According to the telegraphic news from India, General Sir Frederick Roberts has been inspecting the road from Quetta to the Khojak Pass, which is being prepared in anticipation of a railroad being laid down along it in the spring in the direction of Candahar. The statesmen of both parties in England have an invincible objection to calling the proposed railroad by its right name; the Liberals because they pulled up a section and sold the rails for old iron, and then had to lay it down again in a hurry, and the Conservatives because they are not quite sure the public approve of the policy that started the laying down of the Quetta Railway, and do not wish to excite undue alarm. On this account the line is commonly called "the Railroad to the Helmund," the river a little beyond Candahar, where, it is understood, we shall always make a stand against any northern invader. As politics may bring the line into prominence at any moment, it may be opportune to describe its present condition, in connection with its inspection by the Commander-in-Chief in India. From the River Indus the railway runs to Sibi at the mouth of the Bolan Pass. From this point, or close to it, there are two lines to the Quetta district; one 100 miles long through the pass, which is spoiled by the break of the gauge, and will always be a poor line until this defect is remedied; and the other a broad-gauge loop line 156 miles long, *viâ* the Hurnai crossing. The two join at Bostan, 21 miles beyond Quetta. From here a military road, 24 ft. wide, and with a minimum slope of 1 in 20, is being constructed as far as Chaman, an outpost on the Afghan side of the Kwaya Amran range, 70 miles from Candahar. The direct route to this point is not the easiest from the engineering point of view, and we have already had to censure the Indian Government for having procrastinated with its surveys, and caused thereby a standstill at Bostan, while the proper route for the next extension toward Candahar is being sought. At Quetta railway material is being accumulated sufficient to form a line the whole of the remaining distance to Candahar, so that it is sheer affectation and cant to treat the line as otherwise than the future Candahar Railway. Although it is only this week that regular goods traffic has been opened to Bostan, so much merchandise is already pouring into the place that if our Chambers of Commerce were as enterprising as the German trading bodies, this would soon bring pressure to bear upon the Government to complete the line to the emporium of Candahar. In that case the Quetta line would rapidly become a paying undertaking.—*London Engineering*.

Telephonic Communication at Sea.—Mr. H. F. Boyer, of H.M.S. *Malabar*, has recently made a number of experiments in this direction with an apparatus of his own invention. Previous attempts of the same general character by some American electricians have been described. The following description is given of the arrangement: The source of sound consists of a large gong or flat bell supported against the side of the vessel below the water line. A straight tube leads from this gong to the bridge of the ship, and in its interior is a rod fitted with a handle at its upper end, by which the hammer of the gong can

be worked, and the gong struck at will. The striking of the gong may, of course, be done in keeping with a code of signals, such as the Morse code used in ordinary telegraphy. In the center of the gong is fixed a modified Bell telephone with a large and sensitive diaphragm. The telephone is connected by means of wires running up the tube to a second telephone on the bridge within reach of the observer there. This forms the receiving part of the apparatus. If we suppose two ships fitted with this combination, it is only necessary for one to rap out her message by striking the gong and for the other to receive it on her telephone. The sound waves from the transmitting gong traverse the intervening water and vibrate the diaphragm of the submerged telephone at a distance. These vibrations excite currents in the latter, which, in traversing the second or observing telephone, reproduce the original sounds of the gong. Small explosions of gun-cotton under water have also been used by Mr. Boyer in place of the gong; and an ounce of gun-cotton can in this way give a signal which is distinctly heard a mile off under water. Such signals under the sea are independent of fogs or stormy weather; and they hold out the possibility of lighthouses and lightships being able to signal vessels at all times. Moreover, ships, in addition to signaling each other, could also signal lightships, or announce their number to Lloyd's stations, if the system prove successful. Mr. Boyer's plan, which so far has given encouraging results, is somewhat similar to that of Professor Lucien J. Blake, of the Rose Polytechnic Institute, United States. Instead of a submerged telephone, however, it will be remembered that Professor Blake uses a microphone in circuit with the deck telephone as a receiver. With this arrangement Professor Blake has been able to transmit subaqueous signals from a locomotive bell through 1½ miles of the Wabash River, comprising three or four windings. Mr. Edison also is reported to have signaled through a mile of the Caloosahatchie River in Florida during the present year. His system has not been fully disclosed, but it appears to be similar to those described. It is to be hoped that this new development of telephony will be pushed as far as possible.—*London Electrician.*

The International Petroleum Exhibition.—The International Petroleum Exhibition at St. Petersburg, under charge of the Imperial Russian Technical Society, was opened December 27. The London *Engineering* says: "The original intention was to open it December 1, but so many foreign firms applied for permission to fit up installations that the inauguration had to be postponed. The exhibits promise to be of a most elaborate character. Messrs. Nobel, who, by the way, have now $15,000,000 invested at Baku, will show a miniature exhibition of the entire petroleum industry, from the boring of the rock for oil to the manufacturing processes, and the distribution in bulk by tank steamers, tank cars, and street tank wagons. Other firms will illustrate the manufacture of machinery, oil, candles from paraffine, the preparation of dyes from oil refuse, and other technical branches of the industry. One of the most interesting exhibits, however, promises to be a collection of lamps of every age, from those discovered in the tombs of Egypt, Greece, and Rome to the latest productions of Europe. To collect these, the museums of Russia have been ransacked by a commission appointed by the Imperial Archæological Society The display of modern lamps will be also extremely interesting, the offer of prizes for the best safety paraffine and kerosene lamps having caused exhibits to crowd in from every part of the world. We may note, as an instance of the competition English manufacturers may expect, that the Russian firm of Kumberg will show no fewer than 140 different types of lamps. Gas companies should be interested by the display of different systems of illumination by crude oil, paraffine, and oil flares of the Lucigen description. Numerous furnaces will be also fitted up to show the different methods of using liquid fuel. Among the members on the committee are Professor Mendalaeff, who is regarded as the greatest living authority upon petroleum, and a number of scientific men are expected to attend from Germany, France, and Belgium; England being represented among others by Mr. Charles Marvin, whose articles on the Russian petroleum industry three years ago may still be remembered. In general, English lamp manufacturers have displayed great readiness in sending exhibits; but we do not hear of any particular displays by builders of tank steamers, manufacturers of pipes and pumps, and tank cars for railways. As the Germans and Belgians are very freely represented, it is to be trusted that no branch of the industry will ignore an exhibition which, during its three months' existence, will probably be visited by persons interested in petroleum from all parts of Europe."

We are not aware that the United States will be represented in any way. The Russian producers of petroleum are now making great efforts to introduce their oil in the European markets, and this exhibition is intended to call attention to their products.

New Transatlantic Steamers.—The latest designs in Transatlantic steamers are those of two steamers now under construction for the Inman Line between New York and Liverpool, which have longitudinal as well as transverse bulkheads, and twin screws. These vessels—the *City of New York* and the *City of Paris*—are subdivided into many compartments, and there are no doors in the bulkheads below the level of the upper deck. The vessels are sister ships, and are 525 ft. long on the water line, or 560 ft. over all, 63¼ ft. beam, and 42 ft. moulded depth. Their gross tonnage will be 10,000 tons each. They will have four complete decks—promenade, upper, main, and lower, with partial deck above promenade deck and partial deck below the lower deck. The number of complete transverse water-tight bulkheads, all of which are without doors, is 14, so that the average length of each compartment will be 35 ft., or a little more than one-half the breadth of the vessel. But the large dimensions of these ships render even such a compartment one of considerable size, so that there will be no possibility of cramped spaces. The new steamers are fitted with two sets of engines, each set driving a separate screw. The engines are in two separate compartments, subdivided by a water-tight bulkhead, and the boilers are in three separate compartments, completely cut off from each other, so that these vessels might be in collision by being struck on any bulkhead, and could have a break-down in their machinery such as may occur in any ordinary ship, and still be quite navigable and thoroughly safe and seaworthy. While, therefore, the vessels are well provided against the effects of collision, they are also very much better able to avoid collision by having two sets of machinery, one of which could be readily reversed while the other was going ahead, thus turning the vessel.

With the view of avoiding delay outside the bar at New York or Liverpool these vessels have been designed for a light draft; but as it is necessary to have proper immersion for their screws the lightness of draft necessary for crossing the bar will be obtained by the use of water ballast in the double bottom which has been fitted throughout their length. These double bottoms are built upon a new principle specially designed by their constructors, and are believed to be stronger and lighter than anything of the kind which has preceded them. Each has a capacity for 1,500 tons of water in the double bottom, which weight is available for purposes of immersion or stability at the wish of the commander. These double bottoms, it is hardly necessary to say, are a double precaution against injury by grounding. It is anticipated that by the adoption of the precautions of light draft and ample trimming power, the vessels will never have to wait outside the bar at New York. A departure in the machinery department of these vessels is made in the adoption of forced draft on the closed stokehole system, similar to that which has been applied to so many war ships. By the adoption of this system the space and weight occupied by machinery has been considerably reduced, with a considerable increase in cargo and passenger-carrying space.

In order to secure the rapid dispatch and shipment of cargo and coal the vessels will be fitted throughout with hydraulic appliances worked by two independent sets of engines, one in each engine-room, so that in the event of accident to one the other will be at once automatically set in motion. There will be in all 13 hydraulic lifts for cargoes, four for engineers' and firemen's use, and two for steward's use. The steering gear will be worked by hydraulics, and also the cable. The great advantage of this system, so far as the comfort of the passengers is concerned, consists in its complete noiselessness; and any one who has slept, or tried to sleep, on board a steamer when landing cargo by an ordinary steam winch will thoroughly appreciate this advantage. The vessels will have three masts and three funnels; but excepting in the remote contingency of a complete break-down of their machinery, it is not at all likely that sails will ever be set on these vessels. Some of the largest Transatlantic liners, on account of the dimensions which the necessities of the case have forced upon them, are very bad rollers. The dimensions of these vessels are not likely to involve them in defect of this kind; but to provide for the possibility of occasionally meeting seas which may make them roll badly, they will be provided with a rolling chamber, which is really a large tank inside the vessel, extending from side to side, and partially filled with water. The partial filling enables the water to move about freely, and when the dimensions of this chamber and its form are properly selected, the motion of the water can be made to counteract the motion of the ship when rolling. The constructors of these vessels have, after a long series of experiments both on models and in actual Atlantic work, arrived at a form of chamber which will, it is calculated, reduce the rolling by at least one-half.

THE RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

PUBLISHED MONTHLY AT No. 45 BROADWAY, NEW YORK.

M. N. FORNEY, ... Editor and Proprietor.
FREDERICK HOBART. . . . . Associate Editor.

Entered at the Post Office at New York City as Second-Class Mail Matter.

SUBSCRIPTION RATES.

Subscription, per annum, Postage prepaid..............$3 00
Subscription, per annum, Foreign Countries........... 3 50
Single copies.. 25

Remittances should be made by Express Money-Order, Draft, P. O. Money-Order or Registered Letter.

MR. J. HOWARD BARNARD, 7 Montgomery Avenue, San Francisco, Cal., is the authorized Western Agent for the JOURNAL.

MR. FREDERIC ALGAR, Nos. 11 and 12 Clements Lane, Lombard Street, London, E. C., England, is the authorized European Agent for the JOURNAL.

NEW YORK, APRIL, 1888.

THE proposed meeting of the British Iron & Steel Institute in the United States has been postponed for a year. The reason given in an official minute by the Secretary is that prominent members of the American iron trade have advised it, on the ground that public attention will be so largely absorbed by the Presidential campaign next fall, that the meeting will not receive the consideration it deserves if then held.

The visit of the Institute to this country, if present intentions are carried out, will be made in 1889. A decision as to the place and time of the meeting will be made hereafter.

MOST of our readers have heard of the *Stourbridge Lion*, which was built in England, and was one of the first locomotives in this country, having been put upon the Delaware & Hudson Canal Company's railroad line in Pennsylvania by Mr. Horatio Allen many years ago. Some of them probably saw the boiler of this old engine, which was on exhibition at the Chicago Exposition of Railway Appliances in 1883. What was done with the boiler after the Exposition we do not know, nor does it seem easy to procure any information.

The National Museum at Washington has received from the Delaware & Hudson Canal Company a full-sized model of the *Stourbridge Lion*, which was recently constructed in the company's shops from the old drawings, and which was exhibited in the great parade during the Constitutional Centennial in Philadelphia last September. The authorities of the Museum are now anxious to secure, if possible, the original boiler, but have so far been unable to ascertain whether it is still in existence.

If any of our readers have any knowledge of its present whereabouts, they are requested to communicate with Mr. J. E. Watkins, Curator of the Department of Transportation of the United States National Museum, at the Smithsonian Institution, in Washington.

PITTSBURGH papers report that some excitement has been caused among railroad men in that neighborhood by advertisements calling for 500 engineers, 500 firemen, and 500 brakemen to go to China under a five years' contract at high wages. A number of men are reported ready to give up their present situations and go.

As a matter of fact, the only railroad now actually under construction in China is a short line, the building of which is in the hands of English parties who are not at all likely to come to this country for men. Some other lines are projected, but the Chinese move slowly in such matters, and it may be a long time before anything is really done; when it is done materials and men are much more likely to be drawn from Europe than America. There has been talk of a concession to Americans for building railroad lines, but no actual grant has been made. Even if it had, it would be a long time yet before a demand could arise for the services of any considerable number of trainmen. Railroad men would do well to let Chinese contracts severely alone.

ADVICES from the surveying parties employed on the Nicaragua Interoceanic Canal represent that the work so far is proceeding very favorably; no obstacles have yet been encountered, and the Government and people of the country have received the engineers favorably and granted them every facility for their work. So much has been done on the Atlantic side that Chief Engineer Peary expects to start a party from the Pacific terminus early in April.

The Construction Company has succeeded in securing a favorable charter from Congress, and will soon reorganize under that charter. As soon as this is completed, arrangements will be made for the active prosecution of work on the Canal.

THE Army will receive a considerable addition to its artillery material should the bill prepared in committee be passed by Congress. As noted elsewhere, this bill provides for the construction of a number of large guns of approved modern design, and also for the establishment at the Watervliet Arsenal of a thoroughly equipped factory for the construction of steel guns of the largest class. With the facilities now at hand in this country for furnishing steel castings and forgings, this would enable the Ordnance Bureau to turn out guns as fast as we are likely to want them. At present, indeed, there seems to be no pressing need of any; but a modern gun cannot be made in a hurry, and it is just as well to have some ready in case of an emergency.

In this connection it may be noted that the cast-steel gun made in Pittsburgh for the Navy will be ready for trial before very long. Its performance in comparison with the built-up steel guns will be watched with much interest, and the results may do much toward settling some vexed questions.

NOTHING has been said or done in Congress so far in relation to special appropriations for the increase of the Navy. Probably nothing will be brought forward at the present session, partly because other matters claim attention, and partly because the new ships, whose construction

is already authorized, will require all the attention of the Navy Department for some time to come. It is just as well, probably, that nothing further should be done until the new vessels now in hand pass from the experimental and constructive stage into actual use. With a free use of all our present facilities it will be two or three years before the new ships are all afloat, and it will be time enough then to take steps toward building more. Fortunately there is no present prospect that their services will be required in actual warfare, and it is to be hoped that this state of affairs will continue.

If any legislation is to be brought forward this year, it should be rather in the direction of organizing a reserve naval force both of vessels and men ; but so far this has received little attention at Washington, though the discussion has been quite active elsewhere.

THE State of Massachusetts proposes to establish a Naval Reserve on its own account. A bill now before the Legislature, which has received favorable consideration in committee, provides for the organization of naval battalions as a part of the State militia. These battalions are to have their headquarters in the seaport towns of the State, and are to consist each of 100 men, with the proper complement of officers ; they are to be placed on the same footing as the organized land militia of the State in all respects except that their training will be naval and not military. They are to be composed of men familiar with seafaring pursuits and are to be drilled in naval exercises, the use of naval weapons, and if possible in the handling of large guns.

The bill proposes that instead of the annual tour of camp duty, which is a part of the militia service, the naval battalions shall have their yearly training on board ship. For this purpose it is expected that the United States Government will be willing to provide vessels at the proper season.

THE ships now under construction for our Navy will surpass in size and fighting power anything that we have ever had ; but the largest of them is small in comparison with the great warship *Italia*, of the Italian Navy, which is illustrated and described on another page. This ship is equalled in size and weight of guns by only a very few now afloat, and in her construction the builders seem almost to have reached the limit of weight and power possible for a sea-going vessel. One of our new battle-ships would stand very little chance in a direct contest with the Italian monster.

None of these big ships, however, have ever been tried in actual warfare, and their value is still uncertain. For the ordinary service of a navy in time of peace they are not of much use, being too heavy and costly to serve as cruisers, and while they may be almost impregnable against direct attack, it is not at all certain that they might not be outmanœuvered and rendered practically useless by lighter and more manageable ships. In the not improbable contingency of a war in Europe there may be an opportunity for trial of the relative merits of the different classes of vessels which have come into use since the last contest.

IN a recent article on the Nordenfeldt submarine torpedo boat, the London *Engineering* says that the United States Government has decided in favor of these boats as a permanent arm, and is carrying its decision into practice.

Our contemporary is somewhat ahead of the times, the fact being that nothing has so far been done by our Navy Department in relation to the construction of submarine boats except to advertise for proposals for such vessels. Until these proposals are received and considered, it is entirely too soon to assume that the Nordenfeldt or any other plan will be adopted. From the experiments made abroad we have little doubt that these submarine boats are the best and most efficient heretofore constructed. It does not follow, however, that no improvement is possible or that any better plans can be devised. The Navy Department may adopt the Nordenfeldt plan, or it may adopt something entirely new, but no positive action has yet been taken.

RECENT torpedo experiments in England have apparently shown that the charges heretofore used in torpedoes are not sufficiently large. The experiments indicated that 100 lbs. of explosive cannot be relied upon in an attack on a large vessel, and that 150 or 200 lbs. would hardly be sufficient to charge a really formidable torpedo. These experiments also seem to indicate that the locomotive torpedo as controlled from the shore or from a vessel is not by any means as reliable as its advocates claim, and that under many circumstances it would be extremely difficult, if not impossible, to send it where it is wanted.

The fact is, that the more extended the practical experience with torpedoes is the more unreliable they seem to be ; and it is evident that the high opinion that has heretofore been entertained of them as weapons for offense and defense must be considerably revised.

MARCH 12, 1888, will be a memorable day in the history of New York. On that day its citizens had an opportunity to study the condition of a large city deprived of all means of transportation. The storm which came up late on the night of March 11 was the greatest for many years, if not the greatest on record, and on the following morning every line of public conveyance was found to be disabled by the combination of high wind and drifting snow. For an entire day there was hardly any method of travel possible except walking, and that was extremely difficult. The result was a complete paralysis of business, which was more marked as the storm not only stopped movement within the city itself, but also put an almost complete stoppage on all ingress from without and all egress to other places. The city was thus for the time thrown entirely on its own resources, at the very time when they were necessarily limited.

The results of the study were disagreeable, to say the least, and in many cases serious. The mere fact that in so large a population the greater proportion were prevented from going about their usual daily callings, and that the ordinary conditions of life were entirely changed for two or three days, was sufficient to cause much loss and trouble, while cases of serious bodily injury were not few, and those of minor suffering and inconvenience almost innumerable.

Most people recognize in a vague, general sort of way how entirely a large city is dependent for its existence on its connection with the country outside, but it takes an experience like that of the great storm to bring it home to them. New Yorkers who experienced the blizzard and its

results will not soon forget it, and will, for a time at least, have a realizing sense of the power of such a storm.

The whole matter was a curious illustration of the impossibility of freeing ourselves from dependence upon nature. In the presence of certain unfavorable atmospheric conditions the latest and most approved appliances of civilization proved of very little use, and men were compelled to depend on their own physical powers as they have not done before for many years.

ONE of the most noteworthy incidents of the storm was the utter break-down of the elevated railroad system. On the first day of the storm three of the lines of that system were completely stopped. The fourth—the Second Avenue line—which has the lightest traffic of all, and which was, apparently, the one most exposed to injury by the storm, was kept partly open, though trains were few in number, and the lower end of the line, for nearly two miles from the Battery, was not open at all. Such traffic as there was to be carried was consequently thrown entirely upon this line, with the result that the slender facilities it offered were so terribly overtaxed that it was difficult, if not dangerous, to attempt to reach the cars at all.

This result was hardly creditable to the management. By their position and construction the elevated lines are necessarily free from deep drifts or great accumulations of snow. The draw-back imposed by the same conditions is that the use of heavy engines or of several engines together is not possible. The stalling of trains was due, it is said, to the packing down of snow between the guard timbers which are placed on each side of the rails to prevent the wheels from leaving the road-bed in case of a derailment. This is very probable, but it also appears that the road is not provided with any snow-plows or sweepers of even the most elementary kind. The trouble which did occur was just that which might have been anticipated, but no provision had been made to meet it, and, for a time at least, no serious effort seems to have been made to remedy it. It may be noted also that the first attempt to run was made with full trains, no one apparently thinking of reducing the load in the storm.

The whole trouble seems to have laid in two points: a blind reliance upon the advantages of position, and the practice of cutting down expenses to the lowest possible point, without considering whether such reduction may be consistent with a true economy or not. This has always been the policy of the present management, and it is that which has brought it into such general disrepute among the people who see its results. It is true that the storm was one of very unusual violence; but there was hardly even a pretence of unusual effort to meet it.

On the second day of the storm, it must be admitted, the roads did better, all the lines being kept open after a fashion. The running of trains was very irregular, however, and it took more than 48 hours to restore the operations of the road to anything like their usual order.

ONE of the results of the failure of the elevated roads has been a great increase in the disposition to favor new rapid transit projects, and especially the underground lines. While there has been a general talk of the necessity of some additional facilities for rapid transit in the city, the active work on behalf of the new schemes has been, for the most part, confined to those directly interested in the projects or in the development of property improvements through their construction. The average citizen talks about them, and recognizes that something should be done, but has not troubled himself to go further. Now, however, the imperfections of the present system have been presented in so direct and forcible a manner, that the feeling in favor of new lines has received an impetus that it might have required several years to gain under ordinary circumstances.

Most New Yorkers have had great faith in the elevated roads, however much they might grumble at them. They expect the surface lines to give out in a storm, but they have always really felt safe so long as they had the elevated to fall back on in case of emergency. Now this faith has been rudely shaken, if not destroyed, and it can never be fully restored. The tunnel projects have never, to tell the truth, been very popular in New York, and have never received, among the general public, that serious consideration which will now be accorded them.

It is true that some of this feeling and talk will necessarily die out as the memory of the occasion for them fades away, but much of it will remain, and will have weight in determining the result, and especially in aiding to raise money for an underground line, should one of the contending projects secure sufficient legal standing to permit the beginning of work. The elevated roads may have been too severely judged, but the fact remains that public confidence in them has been weakened to such a degree that it can never be fully restored.

THE latest plan for rapid transit in New York is for an underground road to run through the blocks, not following the course of any streets. The projectors' plan includes the purchase outright of all the real estate needed to build the road, and they propose to utilize the land, after the tunnel has been cut through, by putting up on it buildings corresponding in general character with the neighborhood. Four tracks are proposed, with a system of branches connecting with the ferries and railroad stations. The originators of this plan claim that while the purchase of the property will necessarily require a very large sum, a large amount will be derived from the rents of the buildings to be erected by the company, through the cellars of which the road will run.

This plan has rather an attractive air, and may have in it the idea which is to furnish the city with the much-needed additional facilities for travel. In its present form, however, it looks very much as if a big real estate speculation was connected with it. It would be much better to drop the connection, and then more confidence in the company and its scheme, on the part of the people, would be felt.

THE great amount of damage done to the telegraph wires in the East by the recent great storm, and the injury to business and personal inconvenience caused by the almost total suspension of telegraph service over a large section of country, furnish a strong argument in favor of underground wires. Heretofore the burying of the wires has been urged only in a few large cities where poles and lines have been multiplied to such an extent as to become an actual disfigurement to the streets, and a source of danger by interfering with the operations of firemen in case of a large fire. Now the necessity of underground lines through the country, at least to supplement the pole

lines in case of interruption, if not to take their place altogether, has had a practical illustration which has been very forcible in its results.

Electrical experts differ very much as to such lines, although the matter seems quite simple to outsiders. In London and elsewhere in England good results have been obtained from wires put underground in a very simple way, and it would seem possible that the same means would answer here, under a fair trial. That it is desirable to put the wires out of the way in large cities will be generally admitted, and it would seem also that the business interests which depend so largely on the telegraph were entitled to protection against such accidents and interruptions as those lately seen. Such protection could be secured by underground wires, and the cost of replacing the lines destroyed by a great storm like that of March 12 would go a long way toward paying for the change.

For railroads a wire protected against all injury from the weather would have especial value. No inconsiderable part of the trouble resulting from the storm was caused by the failure of the telegraph, which made it impossible to ascertain the whereabouts of delayed trains and prevented free use of the men and motive power assembled to clear the tracks.

An important bill was introduced in Congress at the commencement of the present session, by Senator Cullom, of Illinois, the object of which is to change entirely the system of conducting work on river and harbor improvements. As is well known, this work has been, from its very beginning, under the charge of the War Department, and has been conducted by engineer officers of the Army.

Mr. Cullom's bill proposes to organize a Bureau of Harbors and Water-ways which shall be entirely independent of the Engineer Corps and which shall have an organization complete in itself. This bureau is to have a Chief Engineer, a number of department or supervising engineers, and as many district and assistant engineers as may be necessary to conduct the work in hand. The first appointments in this service, under the bill, would be made after examination as to capability, somewhat on the plan of the Civil Service examinations, and the positions would be open to all engineers who may choose to apply for examination.

Provision for filling up the lower ranks of the bureau in the future is made by providing for the appointment of a corps of cadets, who are to receive the necessary practical instruction in the field, and to be eligible to permanent appointments, as vacancies occur.

This bill meets with favor from the Council on Public Works, which was constituted by delegates from a number of local engineering societies over a year ago. Should it pass, it is probable that it would be regarded only as a commencement, and that an effort will be continued to extend its provisions until the bureau is made to include all public works of the Government, with the exception of fortifications and other exclusively military works.

The bill appears to be somewhat incomplete in its provisions, as might be expected with a measure of this kind, providing for an entirely new system. It is open to criticism and comment, however, and it is not likely to pass for some time, if, indeed, it comes to a vote at all at the present session. It would seem that, if the change is to be made at all, it would be much better to make it complete at once and to organize a single department, which might control not only the river and harbor work, but all the engineering work carried on by the General Government, including the Coast and Geological Surveys, the construction of public buildings, and possibly other scientific work now in progress. Should such a department be organized, the first great difficulty would be to secure a competent head, and the next to prevent the lower ranks from being filled up by men who would secure their appointment by political influence rather than capability.

Possibly the department might not offer many attractions to ambitious young men, as after its first organization promotion would necessarily be slow; on the other hand, there would be the attraction of a permanent position and a retiring pension, both of which will be offered, should the organization be on the lines laid down in the present bill.

Our contemporary, the *American Architect*, recently published a report of a debate in the United States Senate which illustrated in a striking way the lack of system with which the business of designing and erecting our minor public buildings is carried on. The appropriations, in the first place, are made by Congress in a haphazard sort of way, and the work is then thrown upon an officer who is underpaid and overweighted with work. Under all the conditions it is no wonder that numerous abuses have crept in, and that fault is found on all sides. The proper remedy seems to be in a more efficient organization of the work and in the supply of sufficient help to enable the bureau to design and supervise the buildings ordered by Congress. It is, perhaps, expecting too much to hope that that body will ever be very careful in ordering work of this kind, or will preserve a due sense of proportion in its appropriations.

In this connection it may be noted that in many of our larger buildings, both public and private, it would be well if the engineer as well as the architect were called in. We do not by any means wish to disparage the ability of the many able men who are to be found in the architectural profession; but there are many questions which arise in the construction of large buildings which are purely engineering questions, and which a skilled engineer is certainly more competent to decide. Some past experience on railroad work shows that an engineer is very apt to make mistakes when he is called on to act as an architect—and the converse of this proposition may be true also.

The transfer of the Erie Express to the Wells-Fargo Company ends the last attempt made on a large scale in this country by a railroad company to conduct the express business over its own lines. Four important companies have made this attempt—the Delaware, Lackawanna & Western, the Philadelphia & Reading, the Baltimore & Ohio and the New York, Lake Erie & Western—and each in succession has given it up, and has transferred the whole business to one of the great express companies. Two of these companies have made the transfer under the pressure of financial necessity and as a condition of obtaining outside aid; the other two, apparently, because the experiment has not proved profitable, or because they could do better by the transfer. In the Erie case it has been done, most probably, because by it the company secures the large Western business which the Wells-Fargo Company could throw upon its line between Chicago and New York.

The Baltimore & Ohio experiment was continued the longest and most persistently. The Erie Express was started under favorable conditions, was well equipped and managed and apparently prosperous. It withstood an attempt by the express companies to crush it by cutting rates to competing points, and seemed to have reached a solid basis, and to be in a fair way to become a permanent part of the railroad organization.

In none of the cases has there been any detailed or careful statement of the results of this business made public, so that it is not possible to say whether it has been directly profitable or not. There are some obvious advantages in the conduct of the business by the express companies, while, on the other hand, it would seem as if a railroad company with a considerable mileage ought to retain for its stockholders whatever profit there may be in business of this kind. The actual carriage of the express freight over the railroad lines is simple enough, and a railroad company would probably secure much better rates for it by doing the business directly than by hauling it in bulk for an outside company. The organization for delivery and collection of packages in a great number of places, large and small, is a more complex matter, but still one that, it might be supposed, could bear ranged in such a way as to still leave a margin of profit for the company under proper conditions. That it does leave less than can be secured by turning the business over to an outside organization seems to be asserted by the new arrangement which the Erie has made.

THAT "figures cannot lie" is an old adage so often quoted, that most of us have grown up with a sort of superstitious reverence for statistical tables, and an argument which is fortified by a mass of them is apt to be accepted without further question. A French scientific contemporary recently published an article on statistics which contains a very curious estimate of the amount of labor yearly expended by government employés and learned bodies all over the world in gathering up, tabulating, and preparing for publication vast masses of figures on all sorts of matters. Our contemporary goes on to say that these figures are duly printed, indexed, published, and distributed carefully to an expectant public, which receives them with all due reverence—but does not read them. A very few of the volumes thus put forth may be sometimes referred to; others find a resting-place on dusty shelves of libraries, where they are never disturbed, but the majority, alas! come finally to "our old friend, the chiffonier," and through him to the paper-mill.

There is a great deal of truth in this, and our contemporary is quite right in asserting that a large part of the labor to which it refers is really wasted. Most men, as we have said, have a certain reverence for statistics, but most men also do not care to read or study them. The few who do soon learn the melancholy truth that very little wisdom is expended in collecting the statistics of the world. The student who really understands the value of figures will soon find that they are very seldom gathered or presented in such form as to be really useful, and learns not only to regret the amount of time and work thrown away for the want of intelligent direction, but to distrust the value of statistics generally, and to believe that if figures cannot lie they can at any rate be made, either by design or ignorance, to most effectually conceal the truth.

PATENTS AND COPYRIGHTS.

VERY strenuous efforts are now being made to secure the passage of an international copyright law, and thus put an end to the national disgrace which attaches to the fact that robbery of the production of intellectual labor is now legalized in this country. Whether the efforts which have been made to secure the passage of the bill now before Congress will succeed is now uncertain, although its friends are very hopeful of success. The adoption of such a measure would certainly remove the national disgrace which every right-minded and honest citizen of the United States should feel when he or she contemplates the attitude which we occupy in relation to this subject in our dealings with other nations.

The discovery and perfection of some of the new processes of engraving have made the need of international copyright more urgent than ever. By the aid of photography, it is now possible to reproduce, in an electrotype relief plate, a whole page of print, either of the original size or reduced to any desired scale, without setting any type at all. Of course such a copy is an exact duplicate and no proof-reading is needed, excepting to correct defects in the plates. This makes wholesale piracy cheaper, more profitable and more alluring than ever, and the freebooters of the great ocean on which authors launch their boats and ships have now a predatory equipment ready at hand. A piratical "trust" will probably be the next step, unless the American people grow weary and disgusted with the infamy of the whole business and adopt legislation which will finally "establish justice."

On one class of authors the absence of international copyright is especially hard. We refer to those who write on scientific and especially engineering subjects. The value and the labor in such writing is very often largely and not infrequently *chiefly* in the preparation of drawings and engravings to illustrate the subjects written about. With the aid of the new process of engraving, electrotype plates of these and the letter-press can be made, page by page, at a cost of a few cents per square inch, and the books—engravings and all—can be reproduced at only a very small fraction of the original cost. An American engineer who now devotes much time and labor to the preparation of illustrations and to writing a book can have the happy consolation that a foreign publisher may appropriate the results of his work and his knowledge, without leave or license, and reap the profit, and the author is helpless to prevent it. It is hard to see how such a condition of things will aid in developing the literature of engineering in this country. It therefore becomes all engineers to do all they can to secure the passage of the Chace bill now pending in Congress.

Some of the friends of international copyright are relating, with considerable glee, of the way in which a piratical publishing house, which need not be named, has been defeated in its ignoble purpose by the new process of reproducing electrotype plates. This house commenced the republication of an expensive foreign work by the ordinary method of type-setting. They met with one difficulty from the fact that the foreign publishers had a certain number of articles written by Americans and copyrighted in this country. Now the new process men have come along, and are reproducing this same work at about half the cost of the first reprint. How the second

band of—reproducers—will meet the difficulty of the American copyright has not yet appeared.

If the nature of the right of an author to the results of his own intellectual work were better understood, doubtless the injustice of permitting wholesale robbery of foreign authors would soon be ended, and steps would be taken to protect our own citizens from the depredations of publishers in other countries. For some reason, though, the average man seems to be slow in perceiving that if a person puts his ideas into words and makes an instructive or entertaining book, that he has as much right to the results of his labor as a cabinetmaker or a shoemaker has who produces furniture or boots. The mental difficulty in getting at a true comprehension of the rights of authors seems to be that persons are not able to realize that there can be property in a purely ideal thing. A pair of boots or a table is something material, and the maker's right to what he has produced is never questioned ; but they are slow to understand why if a person with very great labor has arranged many thousands of words in such relations to each other as to express ideas, that he should be given the right to the "combination," to use the phraseology of the Patent Office. The labor involved in writing books consists in arranging the words so as to express the author's thoughts. His right is in that arrangement and it is that which the law should protect, no matter whether the author is a native or a foreigner.

In this country the right to a new invention is generally admitted and is recognized by the law. It is based, however, on quite different grounds from a copyright. "The patent system," says a distinguished writer on patent law, "proceeding on the policy of encouraging the exercise of inventive talent by securing to the inventor an original property which, without protection, would have rested only upon a principle of natural justice, takes notice of the exclusive right of that first inventor, and makes it effectual by assuming that he who has first exercised the right of invention has bestowed something upon society which ought to procure for him thereafter, at least for a time, the exclusive right to make that thing."

The essential element in an invention which gives the patent on it validity is its *priority*. The law says, unless you were the *first* inventor you have no rights which will be recognized ; or it promises and grants monopolies, for seventeen years, to those who *first* discover a "new and useful art, machine, manufacture, or composition of matter." A *second* discoverer has no rights under the law. It is the element of *firstness*—to coin a word—in an invention which gives the right to a monopoly of it for a limited time.

This is not the case with books. No two authors ever write the same book. The element of priority has nothing to do with copyright. An author acquires a right to the work he has done by adding one word to another or by a process of aggregation, just as a bricklayer builds a wall by adding one brick to another. Having done this, the law of copyright recognizes his claim and says that no one else shall copy what has thus been laboriously put together. The injustice is in the fact that our law says, We will recognize your right to such an aggregation if you are an American citizen ; if you are not, your rights will not be recognized. The injustice and the shame of it needs no further comment, or ought not to need any, to make it apparent.

New Railroad Building.

COMPARATIVELY little active work on new railroads has been done so far this year ; partly because the season has been very unfavorable for this kind of work, and partly because there is really less to do than there was a year ago. With the enormous new mileage of last year railroad building apparently reached its climax for the present, and this year, while it may see the addition of a considerable mileage to our railroad system, will probably not attain to the figures of 1887. It is true that new projects are continually brought forward and that the organization of new companies is continually recorded ; but in most of the States it is so easy to form a company that a new corporation counts for very little, and only a small proportion of them succeed in transforming their paper locations into actual road-bed and track. There is room for new lines, well placed, in many parts of the country, but there is less disposition to build them.

There are several reasons which can readily be assigned for this. The amount of capital absorbed last year in railroad work was enormous, and while money is not scarce, the amount ready for investment in this kind of work has necessarily been much reduced. It will not be as easy as it was a year or two ago to secure capital for a new enterprise, and it is only companies of standing and established credit which will be able to get what they want without difficulty. This alone will put a considerable check upon extension, and a further one will be found in the higher prices resulting from a period of active demand.

There are fewer long lines of importance begun and to be completed this year than there were last year. Indeed, there are not many long lines now under construction, or likely to be undertaken at once, with much prospect, of success. The Chicago & Northwestern has been credited with the intention of pushing its line through to a new connection with the Pacific Coast, and one or two other similar projects might be named ; but the companies concerned have as yet given no signs of their purpose to push work in such directions at present, whatever their plans for the future may be.

The present indications are that new railroad work during the present year will follow very nearly the lines of last year. Comparatively little will be done in the East, and there is no sign of a revival of the disposition to parallel existing lines there or increase the number of trunk lines, which was so prominent a few years ago. A good deal of work will probably be done in the Northwest in the way of branches into new country, connecting lines and the completion of existing systems. A great deal is promised also in the Southwest, where the building of branches and extensions and the rush to secure territory is to continue, apparently, though with somewhat abated speed. The greater part of this work will be done by existing companies, whose established credit gives them facilities for obtaining money which newer organizations do not possess. In the South there are a number of incomplete lines which may be expected to do something this year, but most of them will probably move slowly.

The evil effects of too great competition have so far developed themselves that a check has apparently been put on the building of new through lines in the country between Chicago and the Missouri River, and little will be done there except in the construction of short lines, for

which room may still be found. An exception may be made in the completion of one or two lines which are now so far on their way that they are sure to be finished this year.

The conditions, it will be seen, while promising a reduction from last year, will still admit of a very respectable total when the figures come to be reckoned up. Just how large the increase will be it is somewhat early to say, but a few months will develop the intentions of a few leading companies upon whose action the total amount of work will largely depend.

A reduction in the new mileage built, however, does not necessarily mean a period of dullness for all the industries dependent upon railroad building. New construction was so pushed last year that rails were laid in advance of the ability of the companies to equip the lines, and there is likely to be a demand for new locomotives and rolling stock for some time to come which will give plenty of occupation to builders, and cause a demand for material. The new lines are not always by any means finished when the rails are laid, and new material will still be called for in their completion and improvement. A prosperous year also is apt to be followed by liberal renewals and improvements on older lines. Altogether there are no indications of a dull year, and the prospects are that there will be work enough to be done to satisfy any reasonable expectations, though there may be considerably less extension of track.

NEW PUBLICATIONS.

GEOLOGICAL SURVEY OF NEW JERSEY: ANNUAL REPORT OF THE STATE GEOLOGIST FOR THE YEAR 1887. Trenton, N. J.; State Printers.

The report of Professor George H. Cook, the State Geologist of New Jersey, for last year is brief, containing only a condensed statement of the work accomplished during the year. This is the case on account of the approaching completion of the work, and because it will soon be followed by the first part of the final report.

The chief work done last year was on the geodetic and topographical surveys of the State, with some investigations into water supply and drainage. The office work done was chiefly in the preparation of the final report.

The map accompanying the report this year comes up to the high standard of excellence which has always characterized the work of the Survey.

MONTHLY PILOT CHARTS: HYDROGRAPHIC OFFICE, UNITED STATES NAVY. Issued by the Navy Department.

These charts are in effect weather maps of the North Atlantic, containing a general summary of the meteorological conditions prevailing over the part of the ocean during the month which the chart covers, with as extensive a forecast as possible of the weather which may be expected during the following month. In compiling these charts information from every possible source is used, and much reliance is placed upon meteorological journals kept on shipboard and returned to the Hydrographic Office. Quite a large number of shipmasters are now interested in the work, and the number of such journals kept has been so increased as to make them valuable sources of information. Of course, the value of such observations increases very rapidly with their number, as an opportunity is given of comparing the work of observers at different points. In order to make the work as effective as possible branch offices have been established in all the principal seaports, from which these charts are supplied to those who desire to have them. Arrangements have also been made to loan standard meteorological instruments to all shipmasters who will agree to keep journals for the office.

The information given on these pilot charts includes attraction, force of winds; limits of trade winds; regions of rain; fog belts with their probable limits; ice and icebergs; position and character of wrecks; probable track of abandoned vessels; routes between leading ports; barometric observations; storm cards and directions in case of cyclones; and much other information of interest and value to mariners.

Weekly supplements are issued from the branch offices giving the weather conditions and other information relating to the Atlantic coast of the United States. It is proposed to extend the work, as opportunity offers, and the Hydrographic Office hopes in time to include the whole maritime world as well as the North Atlantic.

THE LOMB PRIZE ESSAYS ON PUBLIC HEALTH: AMERICAN PUBLIC HEALTH ASSOCIATION. Concord, N. H.; Published by the Association, Dr. Irving A. Watson, Secretary.

The American Public Health Association, an organization which has for its object the promotion of sanitary science, has issued, in pamphlet form, four papers which were selected by the committees of award as the best of a very large number presented in competition for prizes offered through the Association by Mr. Henry Lomb, of Rochester, N. Y. The subjects of these essays and their authors are as follows:

1. Healthy Homes and Foods for the Working Classes; by Victor C. Vaughan, M.D., Ann Arbor, Mich.
2. The Sanitary Conditions and Necessities of School Houses and School Life; by D. F. Lincoln, M.D., Boston.
3. Disinfection and Individual Prophylaxis against Infectious Diseases; by George M. Sternberg, M.D., Surgeon, U.S.A.
4. The Preventable Causes of Disease, Injury and Deaths in American Manufactories and Workshops, and the Best Means and Appliances for Preventing and Avoiding them; by George H. Ireland, Springfield, Mass.

The Association is desirous of securing for these essay, the widest possible circulation, and therefore offers them for general sale at a price simply covering the cost of production, No. 1 being furnished for 10 cents, the other for 5 cents each. They contain much valuable information, and a reading will well repay all who are interested in sanitary science, and that class should include all intelligent people. The paper on School Houses especially deserves the attention of all teachers and professional men. Dr. Irving A. Watson, of Concord, N. H., is Secretary of the Association.

For the current year, under Mr. Lomb's gift, the Association offers a first prize of $500 and a second prize of $200 for a paper on Practical Sanitary and Economic Cooking Adapted to Persons of Moderate and Small Means. The conditions of the competition may be ob-

tained from the Secretary, in whose hands all papers should be placed by September 15 next. The awards will be announced at the next annual meeting of the Association.

BOOKS RECEIVED.

HARPERS' WEEKLY for March 10 has a very interesting article on the "Defense of Our Ports," by Brevet-Major J. P. Sanger, U.S.A. It is well illustrated, the engravings showing modern guns and gun-carriages, and also the proposed iron turret system of defensive works.

PHOTOGRAPHY AS APPLIED TO SURVEYING: BY LIEUTENANT HENRY A. REED, U. S. A. New York; John Wiley & Sons (price, $2.50).

SIXTEENTH ANNUAL REPORT OF THE WATER-WORKS, BAY CITY, MICHIGAN: E. L. DUNBAR, SUPERINTENDENT. Bay City, Mich.; Tribune Printing House.

IMPERIAL UNIVERSITY OF JAPAN (TEIKOKU-DAIGAKU): CALENDAR FOR THE YEAR 1887-88 (XX-XXI YEAR OF MEIJI). Tokyo, Japan; published by the University.

PROFESSIONAL PAPERS OF THE CORPS OF ROYAL ENGINEERS, VOLUME XII, 1886: EDITED BY MAJOR FRANCIS J. DAY, R.E. Chatham, England; published by the Royal Engineers' Institute.

THE CONSTRUCTION OF MAPS IN RELIEF: BY JOHN H. HARDEN AND EDWARD B. HARDEN: ILLUSTRATED. Authors' Edition. Mr. J. H. Harden is Mining Engineer of the Phœnix Iron Company and Mr. E. B. Harden is Chief Topographer of the Pennsylvania Geological Survey. Their paper was originally read before the American Institute of Mining Engineers, and the reprint is accompanied by several illustrations showing their methods of work, and by a photograph of a relief map of the Cumberland Valley in Pennsylvania—a very beautiful piece of work.

MINERAL PRODUCTS OF THE UNITED STATES, 1882-86. Washington; Government Printing Office. The United States Geological Survey has issued a table, arranged by Mr. David L. Day, Chief of the Bureau of Mining Statistics, which shows the quantity and value of the mineral products of the country for the calendar years 1882 to 1886, inclusive. This table is in large type and printed on a large sheet, and is exceedingly convenient for reference and office use.

TWELFTH ANNUAL REPORT OF THE RAILROAD COMMISSIONERS OF THE STATE OF MISSOURI: JAMES HARDING, WILLIAM G. DOWNING, JOHN G. BREATHITT, COMMISSIONERS. Jefferson City, Mo.; State Printers.

TENTH ANNUAL REPORT OF THE BOARD OF RAILROAD COMMISSIONERS OF THE STATE OF IOWA, FOR THE YEAR ENDING JUNE 30, 1887: PETER A. DEY, LORENZO S. COFFIN, SPENCER SMITH, COMMISSIONERS. Des Moines, Iowa; State Printers.

THE PUMP CATECHISM: BY ROBERT GRIMSHAW, M.E.; ILLUSTRATED. New York; the Practical Publishing Company (Price, postpaid, $1).

ACCIDENTS IN MINES: BY SIR FREDERICK AUGUSTUS ABEL, C.B.; WITH ABSTRACT OF DISCUSSION ON THE PAPER. London, England; published by the Institution of Civil Engineers.

MECHANICAL DRAWING: BY LINUS FAUNCE. Boston; W. J. Schofield. This is a brief treatise which was prepared especially for the use of the students of the Massachusetts Institute of Technology. The object appears to have been to present the subject fully and at the same time in the most condensed form possible.

PREPARATORY TRAINING FOR SCIENTIFIC AND TECHNICAL SCHOOLS: BY CHARLES D. MARX, C.E. This is a reprint of a paper read before the Sigma Xi Society at Cornell University, by the Author.

REPORT OF THE STATE BOARD OF HEALTH OF MASSACHUSETTS ON WATER-SUPPLY AND SEWERAGE, JANUARY, 1888. Boston, Mass.; State Printers.

THE ERIE CONTINUOUS STEAM-HEATING SYSTEM. Erie, Pa.; issued by the Erie Car-Heating Company.

MANUAL OF THE PRINCIPAL INSTRUMENTS USED IN AMERICAN ENGINEERING AND SURVEYING: TWENTY-SEVENTH EDITION. Troy, N. Y.; W. & L. E Gurley. This is the twenty-seventh edition of the catalogue issued by this old and well-known house; it contains much valuable information in addition to the ordinary catalogue matter.

THE BENTLEY-KNIGHT ELECTRIC RAILWAY: DESCRIPTION AND ESTIMATES. New York; issued by the Bentley-Knight Electric Railway Company.

Contributions.

Melting and Freezing Points.

BY PROFESSOR DE VOLSON WOOD.

WHEN ice and water are mixed, the highest temperature at which the ice will remain solid is the same as the lowest temperature at which the water will remain a liquid. At the pressure of one atmosphere, this point is not only common both to the ice and water, but is believed to be a fixed point.

But it is an interesting fact that if pure or distilled water be placed in a glass vessel and kept perfectly quiet while it is subjected to a cold atmosphere considerably below ordinary freezing, the temperature of the water may be reduced several degrees below 32° F. before it will freeze; and if the glass be jarred very slightly by a tap of the finger when the water is a liquid at a temperature below 32° F. ice will be instantly formed. This fact is not only known to science, but the experiment has been made at the Stevens Institute. Under these conditions water appears to possess the ability of maintaining its state of aggregation to a limited extent, but the condition is one of unstable equilibrium, for the slightest disturbance produces a change of aggregation. On the other hand, so far as known, the temperature of melting ice is a fixed point, at a fixed pressure. The kinetic energy of the molecules, supposed to be increased by the action of heat, prevents the condition of indifferent equilibrium. When an experimenter desires to determine the temperature of a liquid very accurately he gently stirs the liquid before reading the thermometer; and, if a magnifying glass be used, it will be observed the reading of the thermometer is not the same before the liquid is stirred as after.

THE PRINCIPLES OF RAILROAD LOCATION.

By Professor C. D. Jameson.

(*Continued from page* 110.)

CHAPTER XV.

THE TOPOGRAPHER'S WORK.

The outfit of the topographer consists of a thin drawing board 21×26 in., on the back of which is a waterproof pocket and a flap, both the size of the board. In this pocket are carried the sheets, 19×24 in., upon which the work is to be plotted. He must also have a small paper scale, pencils, rubber, thumb-tacks, etc.

Figure 1.

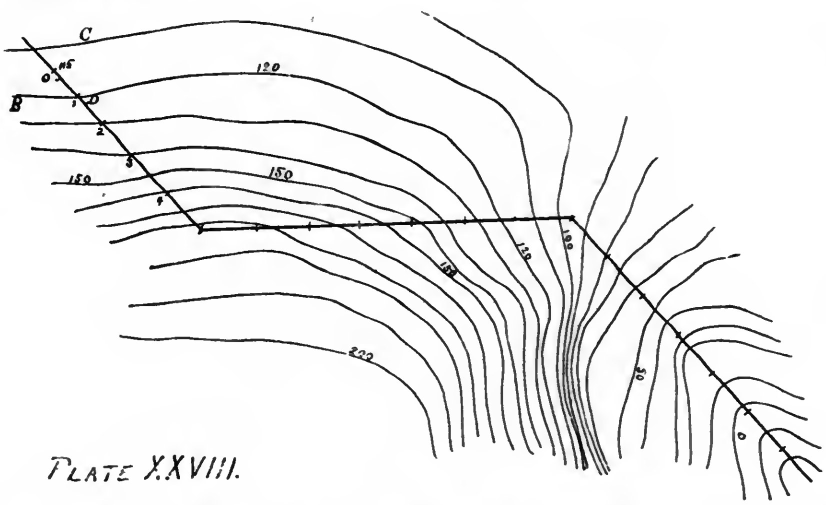


Plate XXVIII.

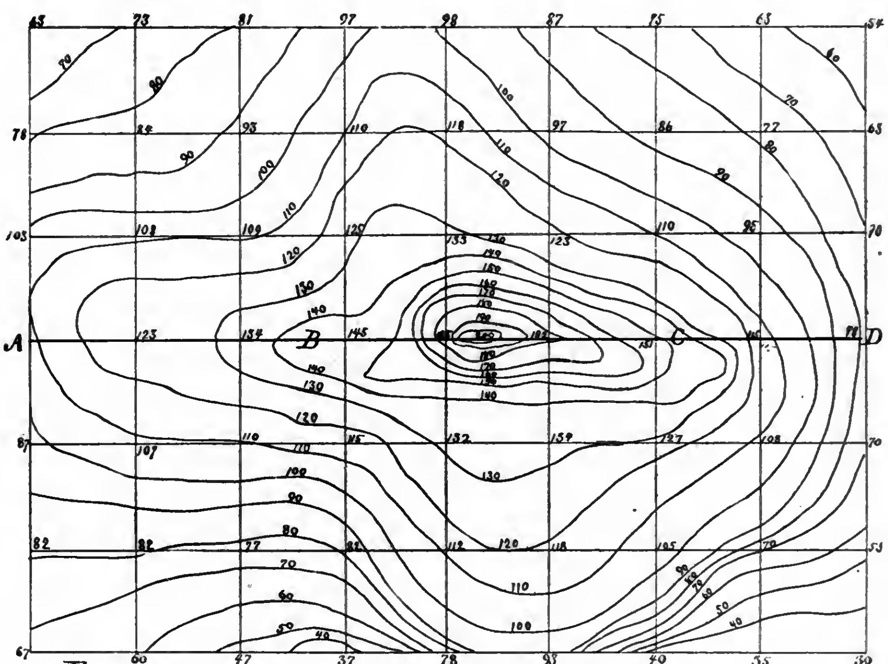


Figure 2.

The sheets should be of a light green color, if possible, as working in the sun on white paper is very bad for the eyes. The assistants have a tape-line, hand level (which may be used to advantage under some circumstances), and a small hatchet, besides the rods or clinometer and board rod.

On the sheets which the topographer has he plots the line as run by the transitman, and at each station the elevation, as given by the leveler, is lightly penciled.

The head assistant has the elevation of each station, and commences by measuring off, by means of the rod, to the contour next below or above the station, as in Plate XXVIII, fig. 1.

Commencing at station 0, which has an elevation 115, he finds the point *B* of the contour 120 and the point *C* of the contour 110. The topographer, taking these distances, plots them at once, and by his eye puts in a short piece of the contour. The assistants also give the points where-ever the contours cross the main line, as contour 120 crosses the main line at *D*.

The topographer then moves ahead one or two stations, and, getting the points of the different contours, works backward to connect with what he had before, and sketches in very lightly the supposed direction of the contours in advance.

He should keep notes of the readings of the rods or clinometer, but merely as a check on his work, as the lines should all be accurately plotted in the field.

The most convenient scale for railroad work in an ordinary country is 200 ft. to the inch, and in a rough

country 100 ft. to the inch. Much time is lost by trying smaller scales, such as 400 or 600 ft. to the inch, and also much is lost in accuracy.

With practice and a quick eye the work can be kept well up with the other parties.

When the distance each side of the main line that is to

PLATE XXIX.

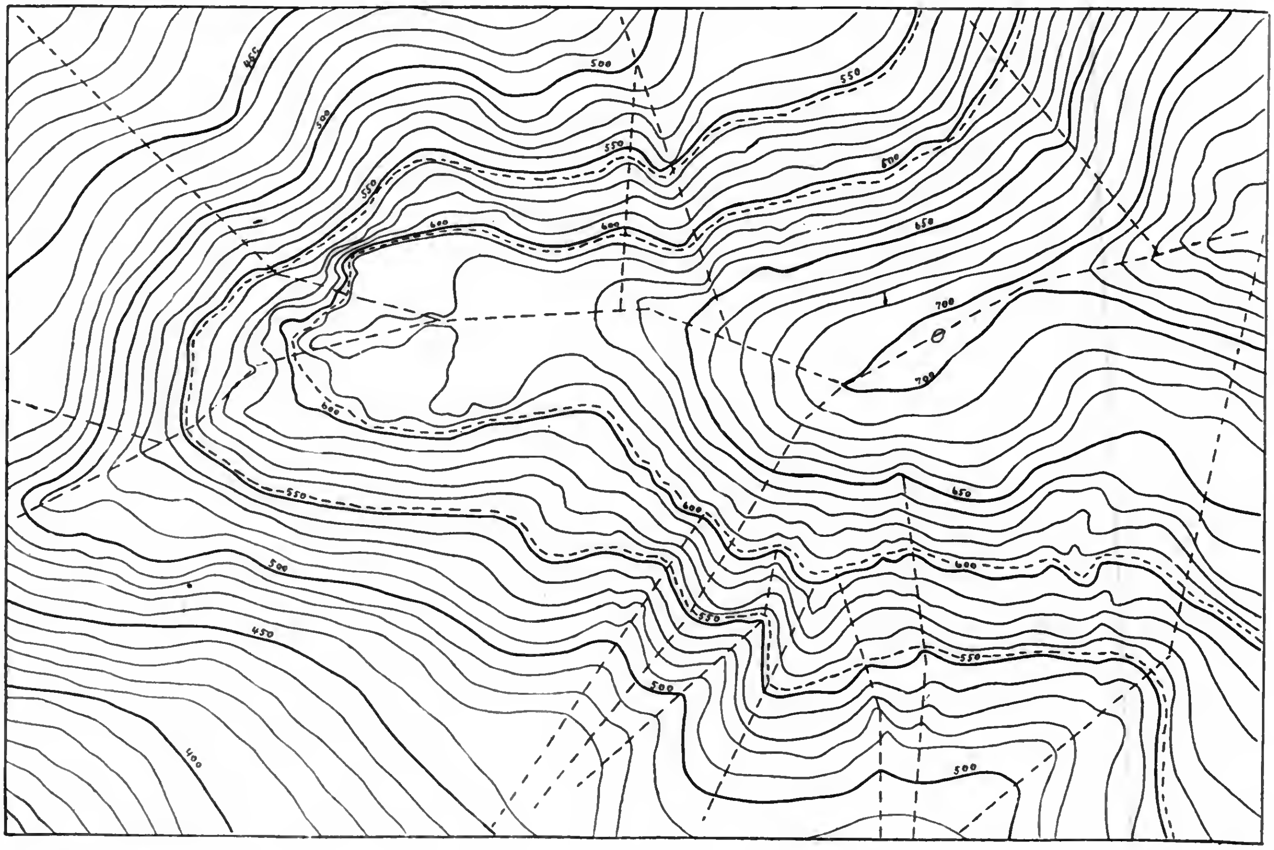
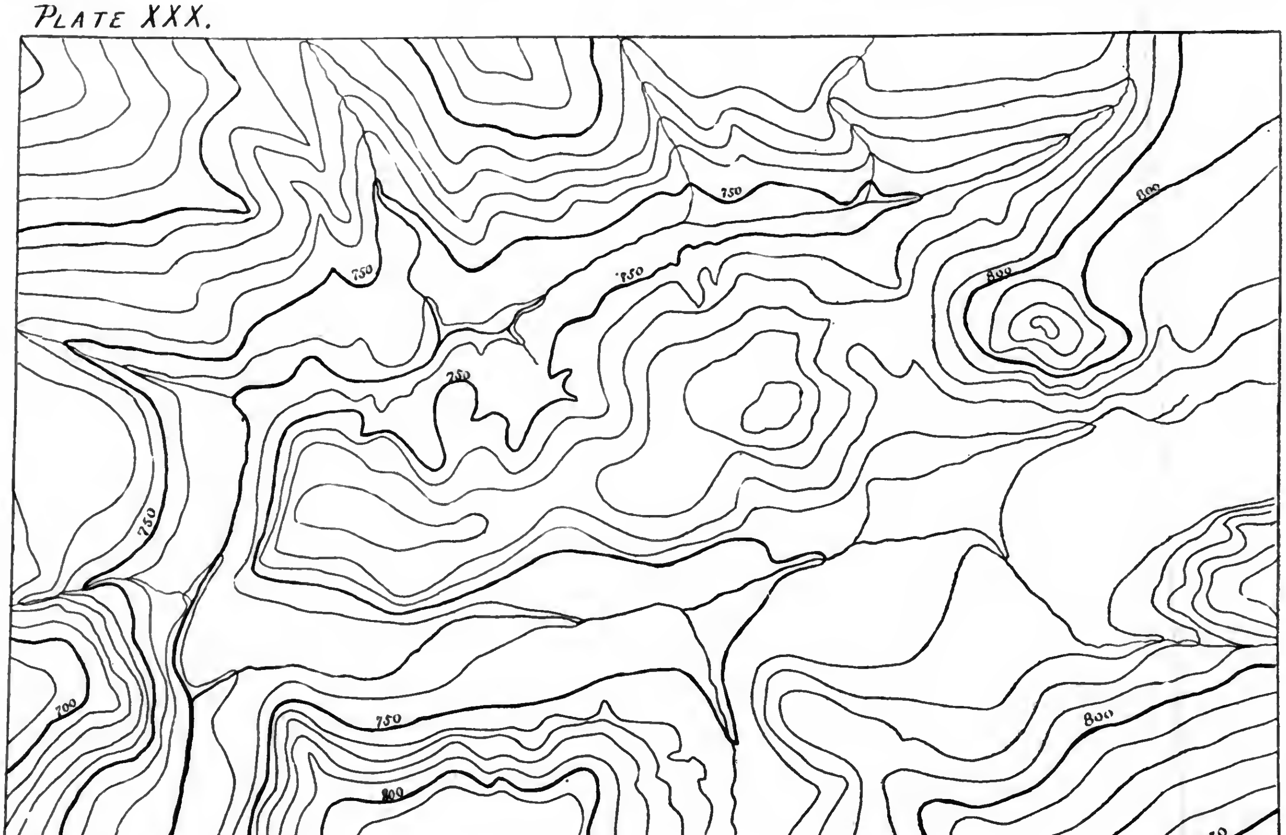


PLATE XXX.



The work of the topographer is slow if it is accurate, and unless accurate is worse than nothing. In it, as in every branch of the survey, much depends on the person.

be surveyed for contour lines is more than 200 ft., it is often more saving to time and conducive to accuracy to cross-section it with a wye level in the following manner

(Plate XXVIII, fig. 2): Let the plate represent a broad belt of country which it is desired to make an accurate contour map of. *A B C D* is the transit line. Then from every second or fourth station, according to the character of the country, run offset lines, at right angles to the main line, with either the transit or a surveyor's compass, and take the elevation of the stations on these lines with the wye level. All of these lines are then plotted and the elevation of each station lightly penciled in, and the contours then worked out from these elevations. It will be seen that any way the work is done it is a slow, tedious job, but when done accurately and the belt of country contoured is not too wide, it is money well spent for the railroad company.

The width of the country taken in should include any possible changes between the preliminary line and the final location.

The amount of detail taken by the topographer must depend upon the character of the country, and is left to the judgment of the engineer.

The topographer not only obtains the data necessary for the contour lines, but he must also plot all the watercourses, line fences, buildings, etc., that come within the boundaries of the strip of land he is taking, also the different kind of land over which the line is run, the material, whether earth, rock, or hard-pan, the state in which it is, whether wooded, swampy, cultivated, etc.

We have described the methods in general use for obtaining the topography of a country.

Those methods where the distances are actually measured, such as with the clinometer or cross-section rods, are called cross-sectioning, and can only be used for comparatively small distances.

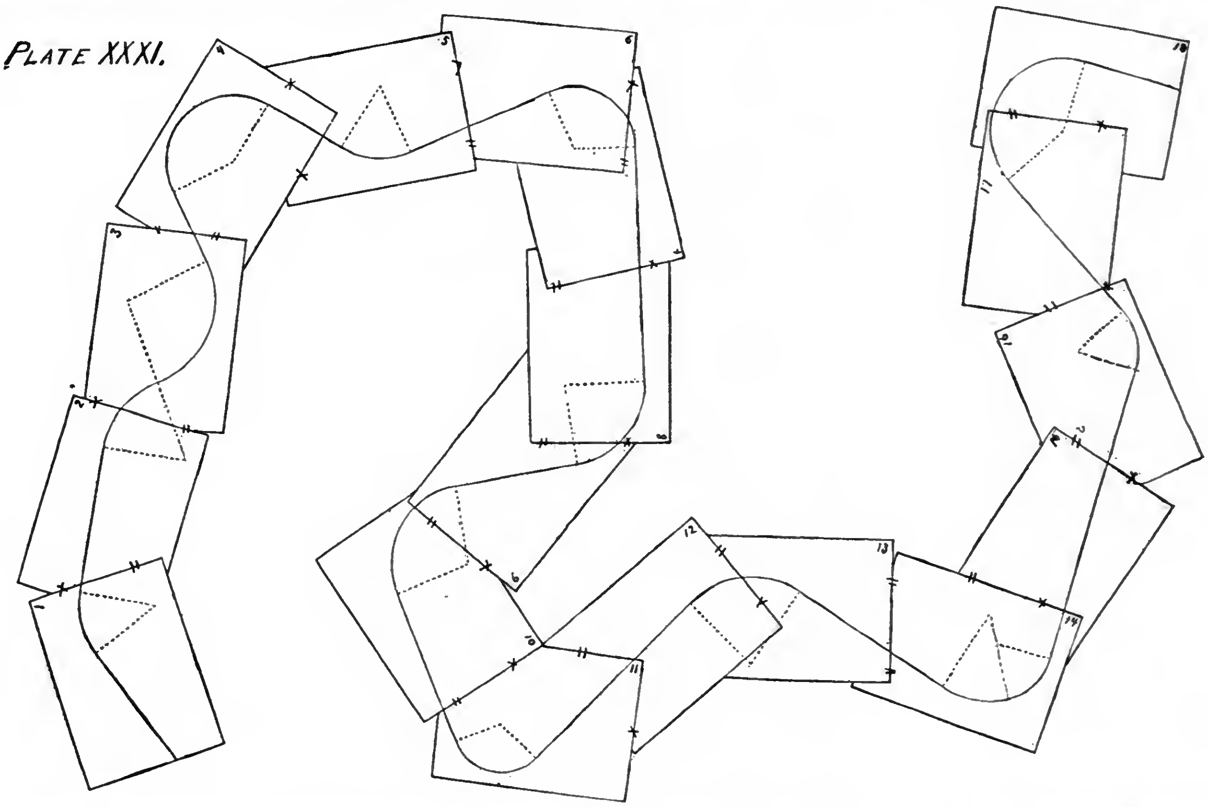
The quickest and most satisfactory method of all is by the use of the stadia, which has been fully described in the preceding chapter.

There is still another method used for obtaining a contour map of the country, and this is used when the extent of the country which it is desired to contour is so great as to practically exclude the use of the cross-section rods or clinometer, or the dividing of the country up into parallelograms and taking the elevation of the corners.

This manner of proceeding is to run lines with either a transit or compass over all the prominent topographical features, such as up the ravines, on the crests of the ridges, and, in fact, as nearly as possible over all points where the contour lines will make sudden changes in direction. Plate XXIX well represents this method of making a contour survey. The lines that would have to be run on the ground, in order to procure sufficient data to make the map, would be about where the dotted lines are, with the contours about 10 ft. apart vertically.

As a matter of fact, Plate XXX was taken from a map made for the actual location of a railroad line, in which the contour lines, as represented here, were 32.8 ft. apart vertically; the contours of the original map were put in every 6.56 ft., only every fifth contour having been kept.

PLATE XXXI.



The railroad location for this piece of country (the line, as yet, has not been constructed) was a most wonderful combination of spirals upon spirals, and is shown in detail, with full explanations, in the "Economical Theory of Location," by A. M. Wellington, page 684. The location was made by Mr. Wellington himself on the Pacific Line of the Mexican Central Railroad.

While making a survey in the field, all the work that is done each day, with transit, level, or stadia, should be plotted each night, in order that the Chief of Party can decide whether any of it must be done over again or whether the work shall go ahead.

The transit line should never be plotted on a long roll of drawing paper, unless there is very little curvature or topography. The reason of this is that it is extremely awkward to carry, and requires a large table upon which to spread it for plotting, and when there is much curvature in the line it is continually running off the paper. The

PLATE XXXII.

TRANSIT-BOOK. PRELIMINARY.

Station.	Points.	Description of Angle.	Calculated Course.	Magnetic Course.	Topography.	Remarks.

PLATE XXXIII.

TRANSIT-BOOK. LOCATION.

Station.	Points.	Description of Curve.	Elements of Curve	Magnetic Course.	Topography.	Remarks.

PLATE XXXIV.

LEVEL BOOK.

Station.	+ Sight.	Heigt of Instrum't.	– Sights.	Elevation.	B. Ms. & T. Ps.	Remarks.

only proper way to plot an ordinary line in the field is to plot it on separate sheets, about 19×20 in. These sheets are added, one after the other, as the work progresses, the axis of each sheet being placed so as to make it coincide as nearly as possible with the center line of the survey. Each sheet laps under the preceding one, and at the edge two or more crosses—× × ×—are made, in order that they may be fitted together again in the same actual position. Plate XXXI. shows a number of these sheets put together, giving the line as laid down.

While these sheets are being worked upon, they are pinned down to the drawing-board with ordinary thumb-tacks. The size of the drawing-board is only large enough to pin down two or three sheets at a time.

Each sheet should be numbered in the corner, and should have a north-and-south line laid upon it.

In plotting the work a large paper protractor is laid upon each sheet, on the north and south line, over a permanent center and pinned down. The bearings of all the lines that will come on that sheet must be pricked off at once. Then remove the protractor.

Then, with a pair of triangles, carry the bearing of each line to its proper point, run it in, and scale off the length.

CHAPTER XVI.

NOTE-BOOKS.

The following are the note-books that are used on a railroad location. First the note-book of the Chief of Reconnoissance, in which is contained not only all the data which he can obtain from existing maps of the country through which it is proposed to run a railroad, but also the data obtained by him in a personal examination of the country.

This note-book should contain full sketches of the country, showing courses of the streams, lines of mountains, and other topographical features, the rate of flow of the streams, together with notes of their size and the probable amount of water which they discharge, the elevations of the different dividing ridges between the water-sheds and the area of the water-sheds ; also copious notes as to what material the ground is composed of over which the road must pass—that is, whether it is rock, hard-pan, or earth, also the condition in which this material is, whether it is swampy or dry, covered with wood or clear, whether barren or under high cultivation. There must also be notes as to all possible bridges, trestles, tunnels, etc. In this respect notes can only be made as to the more important structures, as the smaller ones are only developed on the preliminary survey. There should be notes on all the resources of the country, both developed and undeveloped—that is, the resources as they actually exist at the time of the reconnoissance, and the resources which, by the introduction of the proper means of transportation, may be developed into paying business, and furnish traffic for the road.

As we have said, the future financial success of a new railroad depends not so much on the present traffic or the traffic which exists at the time the road is built, as upon what the future traffic will be. Therefore; the future traffic is one of the most important things which is to be studied.

There should be notes as to the different classes of resources ; whether it is a mineral country, an agricultural country, or whether, owing to the presence of great water-power, it may become a rich manufacturing country.

All these notes should be as full and explicit as possible, nothing being left to the memory of the Engineer. Always, on a reconnoissance, the Engineer should carry another small note-book in which to keep notes of the barometrical readings used in obtaining the elevations of the various points ; the readings of the hand-level should also be kept in this book. Barometrical readings, after a reconnoissance, should be all worked out and corrected, and the results copied into the regular note-book of the reconnoitring engineer.

The TRANSIT BOOK, PRELIMINARY LINE, should be of convenient size to carry in the side pocket of the coat, have stiff covers, and be ruled as shown in Plate XXXII, which represents two pages of a transit book. The right-hand page (not shown), in addition to having a heavy line in the center, which is usually in red, is divided by vertical lines, eight or ten to an inch, which serve as a scale when sketching any features of a country, on each side of the center line.

This heavy line in the center is always considered as representing the line that is being run. The headings of the different columns explain clearly what must be recorded in each.

In keeping transit or compass notes, always begin the notes at the bottom of the page and work from the bottom toward the top. The reason for this is, that when in the field facing in the direction in which the line is being run, and holding the transit book in your hand, the heavy line on the right-hand page, running from the bottom to the top of the page, is running in the same direction as the line is being run, and any topographical notes, either on the right or left of the actual line, can be noted in the book on the right or left side, as the case may be, of the heavy line in the center of the page, thereby obviating, to a great extent, any chance of confusion as to the different sides of the line.

The TRANSIT BOOK, LOCATION (Plate XXXIII), is similar to the transit book used on the preliminary work, the principal difference being that in this case curves are used to join tangents in the place of the tangents meeting at an angle, and the headings of some of the columns are changed to accommodate the required elements of curve.

The LEVEL BOOK (Plate XXXIV) is the same size as the transit book, and is ruled as shown. The right-hand page is left blank in order to receive any necessary remarks and descriptions. It is here that full description of all bench-marks and permanent points are made.

The headings of the different columns may be either as in Plate XXXIV or in Plate XXXV, both forms being much used and very convenient ; some engineers prefer one and some the other.

The older form of keeping level books, where plus and minus readings are put in the same column, with proper signs prefixed, is now obsolete.

RELOCATION NOTES (Plate XXXVI) are prepared from the plans of the preliminary line and the contour maps which have been made. The line is located on paper and then the proper notes prepared, showing the alignment of the lines to be run in on the ground. These notes serve more as a guide than as the actual notes of a line which must be run whether it fits the ground or not upon trial, because, no matter how exact the contour map is made from the notes taken on preliminary survey, it is impossible to make a paper location in the office that will actually be the best line that can be run on that ground, and where it is not the best line and the points where it is to

PLATE XXXV.

LEVEL BOOK.						
Station.	+ Sight	Height of Instrum't	− Sight.	Rod.	Elevation.	Remarks.

PLATE XXXVI.

TRANSIT-BOOK RE-LOCATION.						
Station.	Alignment.	Central Angles.	Length.	Magnetic Bearings.	Topography.	Remarks.

PLATE XXXVII.

CROSS SECTION BOOK.									
Station.	Surface	Grade.	Cross Sections.		Excavations. L. Rock.	S. Rock.	Earth.	Embankment.	General notes.

be corrected to adapt it to the surface of the ground can be easily seen and must be changed in the field.

The CROSS-SECTION BOOK is shown in Plate XXXVII. The headings of the different columns show so clearly what is to be recorded in the columns that no other explanation is needed.

The form of the STADIA NOTE-BOOK was fully explained on page 107 (March number).

All of these notes should be guarded with great care and duplicates of them made as soon as possible, as they are the official record of what work must be done, and the only record whereby any calculation can be made as to the amount of work that is to be done at any time.

CHAPTER XVII.

THE OFFICE FORCE.

In keeping notes of the work done in the field the utmost care should be used that all notes of the same kind should be kept in exactly the same manner—that is, all the transit notes should be kept in the same manner, and the same letters should in every case be used to denote the same thing. The object of this uniformity is that although the notes are all worked out and plotted in the field, these original note-books are all sent into the main office, and there plans made from them by draftsmen who have never been in the field and know absolutely nothing of the work, in many cases, except what they see in the note-books.

Unless the notes of all the different engineers are kept with perfect uniformity much time is lost in studying out the different methods used, and the danger of inaccuracy in plotting is very much increased. One rule, which the Chief of Party should fully impress on all those working under him who are taking notes, is this perfect uniformity of methods, and he should not only impress this rule, but should know that it is obeyed in all cases and that the notes are full and explicit.

No engineer should ever trust to his memory for any facts in regard to a survey which he is making which may at any time, as far as can be foreseen, be of any use.

The draftsman who makes the plans of the work done in the field has nothing but the note-books to guide him, and unless these notes are full, plain, and explicit in every detail, the plan made from them will be absolutely worthless. These notes should be full and explicit, also, because they form by far the most valuable record of the work done. All the original note-books should be carefully preserved, and as soon as they are sent in to the office copies should be made of them in ink, and then the original note-books and the copies should be filed away in fire-proof safes, in separate places. These duplicates should be made by one person and checked by another.

In all engineering work it is a good plan to have all calculations checked by some person other than the person originally making them.

Of course the number of persons employed in the main drafting office of a railroad depends entirely upon the amount of work which is being done and the speed with which the work is being pushed.

There should be a Head of the Office, who reports directly to the Chief Engineer, and who is responsible for the amount and character of all work done in the office. He should be a competent engineer, who has had some field practice, a good draftsman, and have sufficient executive ability to command order and have the proper amount of work done in the desired manner.

There should be one bridge expert, who can calculate quickly and correctly what will be needed for the different bridges, trestles, etc. He should be able to check any calculations sent for consideration by the different bridge companies who may be bidding for the work, and he should have had some practical experience with some bridge company in designing and erecting the work.

There should be one man who understands architecture for the designing of station-houses, freight-houses, shops, etc. Also one or two who thoroughly understand plotting from field notes and calculating quantities. Lastly, there should be one man who is in every way a finished draftsman for finishing up in an artistic manner any map upon which it is deemed advisable to put this extra amount of work.

There should be one or two young men for making tracings, copying notes, etc., and a boy to attend to the blue prints or whatever reproducing process is used.

The above list of employés is not meant to give an idea as to the actual number that should be employed in any one case, but simply to give some idea as to the work which is to be done in the main office.

On some roads where the work is being pushed slowly and there is not much of it, one man, or at most two, may embody all of the above requisites, while on the other hand, on large works which are being pushed rapidly, there may be required several men to fill each of the above positions, with the exception of the Head of the Office.

(TO BE CONTINUED.)

HYPERCYCLOIDAL GEAR.

By ALOHA VIVARTTAS.

THE principal characteristics of the gear teeth formed upon the hypercycloid are that while having the quality of perfect interchangeability—that is, gear of all the different numbers of teeth running together equally well—they not only fill their engaging spaces upon the pitch line, but also to the point of the tooth, making when on the line from center to center of the gear an absolutely close fit, as shown in fig. 1.

This gives fully 25 per cent. more strength than any other form of tooth of equal pitch and face by the additional material left at *a a*. It also gives 50 per cent. more wearing surface than other forms, since the part *b* runs smoothly against the whole surface from *a* to *c*.

This curve, as its name implies, is one of the cycloidæ, but to describe it in the ordinary manner, the scribing point is made to project beyond the rolling or generating circle, and the curve is scribed across the generatrix or pitch line; the portion of such curve used being mostly on the farther side of the pitch line from the generating circle, for a gear tooth from pitch line out works beyond or within the pitch line of the engaging gear.

On examining fig. 1, it will be seen that both the form and also the dimensions of both the tooth from pitch line outward and the space from pitch line inward in which it works are identical; and as this must be so in all cases, without regard to the number of teeth in either wheel, it follows that the cutter or template that would make the space from pitch line in for one wheel would be correct for all wheels of that pitch from pitch line in. And again, a cutter or template fitting the tooth from pitch line out would likewise fit the tooth of every wheel of that pitch.

This is the fact, and a male cutter cutting the spaces *a a c c* with a female cutter finishing the teeth *b b c c*, each working true to radial center line, as shown in fig. 2, is the practice in the shop.

The propriety of thus considering the tooth from pitch line out, independently of the space between the teeth

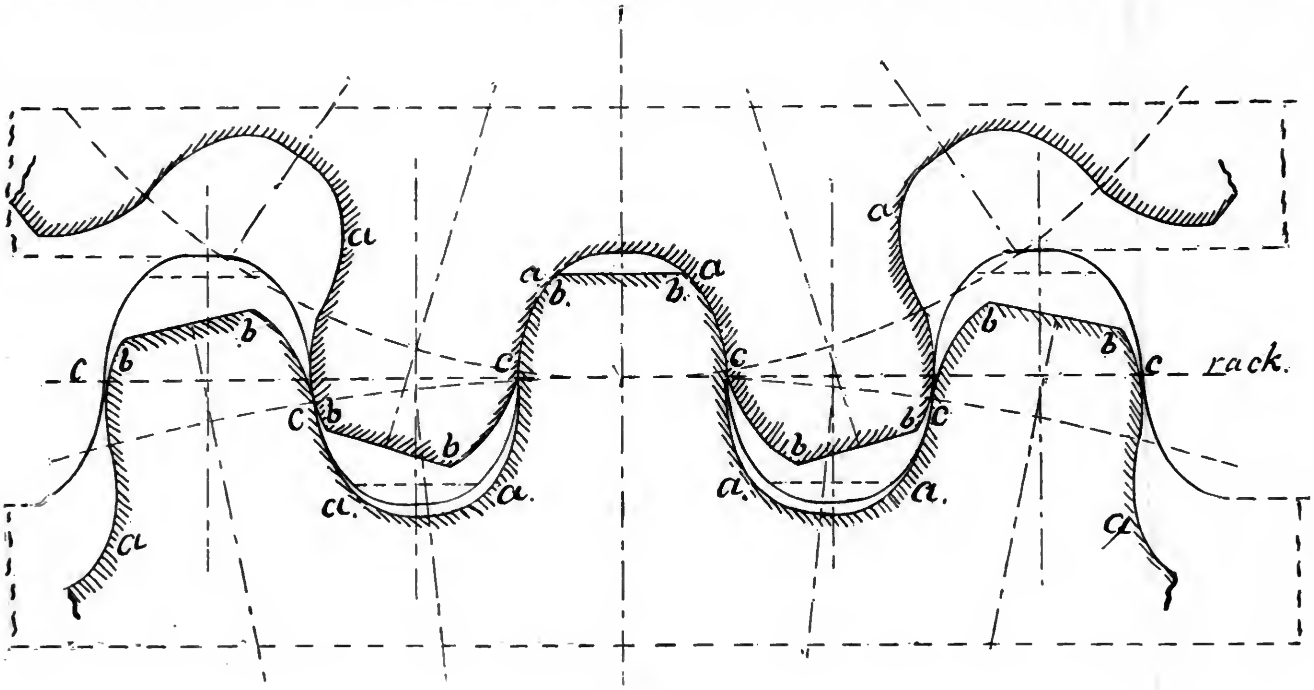


Fig. 1.

from pitch line in, is apparent by referring to fig. 3, which illustrates a method sometimes practised for equalizing the strength of the teeth in wheels of different materials, as wood and iron. In this case it is seen that a tooth of 1 in. pitch (as commonly considered) on one wheel may run

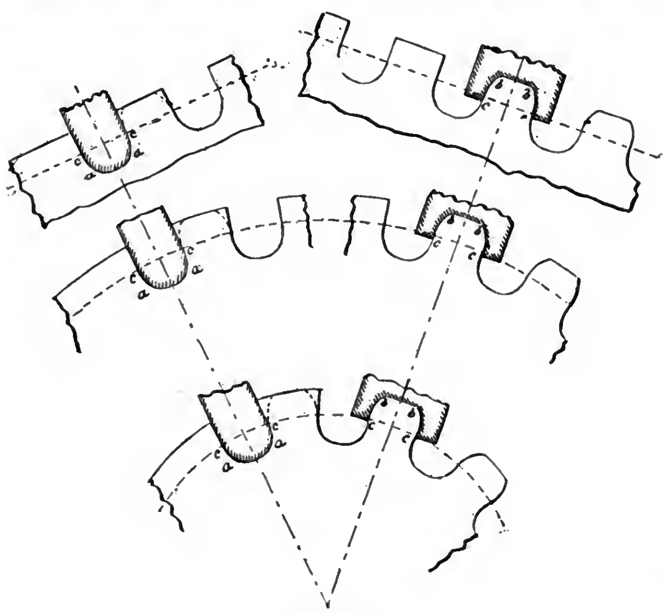


Fig. 2.

with a tooth of ½ in. pitch upon the other wheel, giving a resulting pitch of ¾ in.; yet the wheels will run as perfectly as if the teeth were all alike. Observe that the teeth of either wheel project beyond their pitch lines according to their own size only, and wheels of this kind with equal numbers of teeth show different outside diameters.

This is generally an especial tooth, but admits of the principle of interchangeability so far that any wheel of the major tooth will run with any wheel of the minor tooth, and *vice versa*. This has also been done with worms and their gear.

In making internal gear, the principle illustrated in fig. 3 is applicable with good effect, but the best practice is to make the internal gear with only spaces within the pitch line, and omitting the teeth that would project beyond the pitch line entirely, as shown in fig. 4. In this, the pinion may be made especially for such gear, as *h*, with only teeth from pitch line out, and no spaces within the pitch line; or the pinion like *i* may be of the ordinary standard

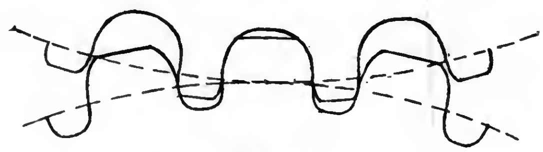


Fig. 3.

and run with other gear if desired. Either will run perfectly smooth and without backlash.

In the case of elliptic gear the same general principles apply, and the fit, strength, wearing surface, and smooth-running qualities are all maintained, due care being taken to cut each tooth true to its center line, which is not to be mistaken for the line from such tooth to the center of the gear, but which varies therefrom according to the location

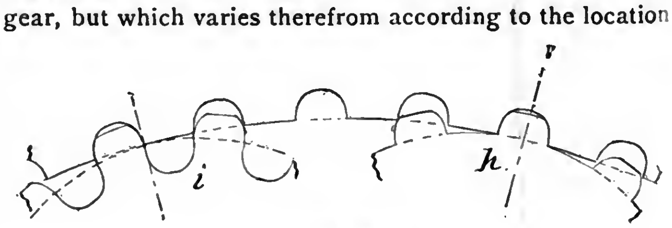


Fig. 4.

of the tooth, the extreme distance between the intersection of the center line of tooth or space, with the transverse diameter of the ellipse, being a third proportional to the distance between the foci and the length of the transverse diameter.

Such center line for any one tooth or space is easiest

found as shown in fig. 5. Draw a line from the center of the tooth on the pitch line to each focus, bisect the angle at the center of the tooth, and cut on such resultant, which is perpendicular to the tangent of the ellipse at that point, and consequently, as two elliptic pitch lines touching each other have a common tangent at the point of contact, the tooth on one pitch line will fit fair in the space within the other.

In chain or sprocket wheels, the chain generally works to the wheel as the extreme of the tooth of a rack, as *b b*,

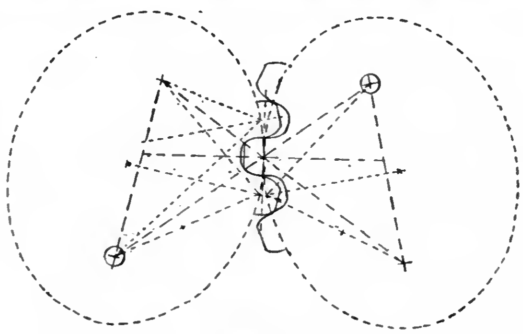


Fig. 5.

fig. 2, and as the chain works to the one side of its natural pitch line so the wheel is entirely, or nearly so, within its own pitch line, and shows little but spaces within the same, and no teeth proper.

In worm gear the section of the worm is the counterpart of the rack ; the gear is turned exactly the proper diameter

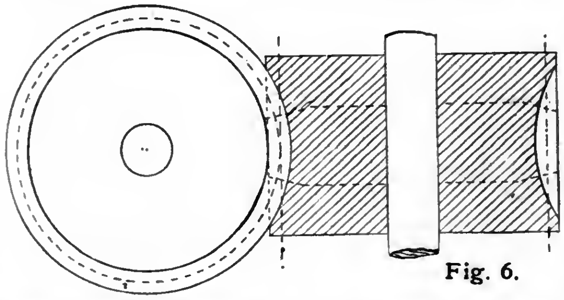


Fig. 6.

for a spur of the same pitch and number of teeth, but should never be hollowed to follow around the barrel of the worm, as all such excess of diameter interferes with its proper action, and causes the center of the tooth to undercut in making or wearing, weakening the tooth and doing no good. But a straight cylinder with the worm cutter driven into it just the depth of the tooth and space, as in

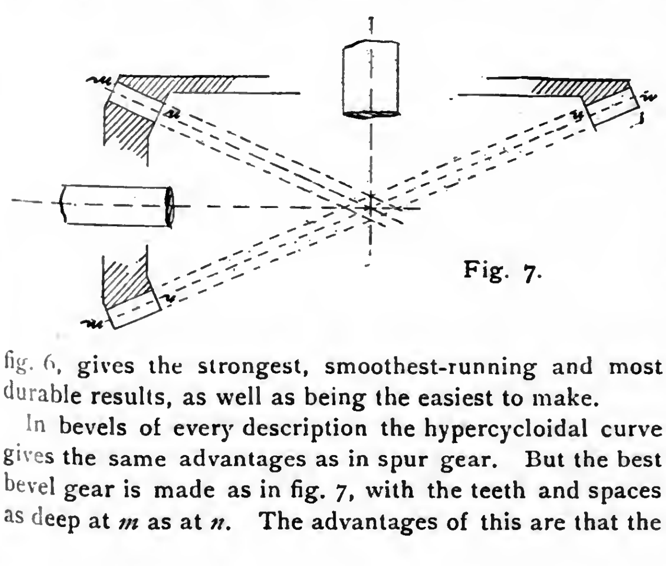


Fig. 7.

fig. 6, gives the strongest, smoothest-running and most durable results, as well as being the easiest to make.

In bevels of every description the hypercycloidal curve gives the same advantages as in spur gear. But the best bevel gear is made as in fig. 7, with the teeth and spaces as deep at *m* as at *n*. The advantages of this are that the gear are always working the whole length of the face from *m* to *n*, whether running exactly on pitch distances or not, while any wear of the journals does not throw the labor on the outer end of the teeth, as in the conoidal pattern, unless the angle of the shafting is changed. This gives greatly augmented strength and durability with the same weight of metal.

These gear are easier to make correctly than the conoidal tooth, and with the same tools will fit as closely and perfectly throughout from *m* to *n* as spur gear.

THE ITALIAN BATTLE-SHIP "ITALIA."

(From the London *Engineering*.)

THE accompanying illustrations are a general view of the Italian armored ship *Italia* and a view of the upper deck, or top of the casemate. This vessel has aroused more interest in naval circles than any other warship since the French *La Gloire*, which was the means of introducing armor-plating as a method of defense for first-class ocean-going war vessels. This, we think, may safely be said without even excepting our own *Inflexible*, and the protracted inquiry and controversy which resulted from the strictures pronounced on that abundantly discussed ship.

The *Italia* and her sister ship, the *Lepanto*, were commenced about 10 years ago. In design they were an immense step on anything that had preceded them. Whether the step was in the right direction or not is a very much disputed point, on which many of the highest authorities in the science of naval construction all over the world hold diametrically opposite opinions. But one cannot help admiring the courage of the Italian naval authorities in laying down these two vast and costly ships, comprising so much in their design that was open to criticism and necessarily involving features of doubtful advantage. This reproach, however, may be brought against all modern warships, for the absolute data we have to go upon in the present day is of so meager a character that no one can pronounce with any degree of certainty what would be the practical fighting value of any particular class of design. Until the world sees a great naval war every one is entitled to an opinion, and hence the vast gulf that divides the doctrines of our most renowned professors.

The *Italia* was built at Castellamare, on the Bay of Naples, and the *Lepanto* at Leghorn. It will be remembered that in 1877 the Italian Parliament sanctioned what may truly be described as a spirited naval policy. It was decided to build 16 battle-ships of the first class, 10 of the second class, and 20 cruisers. Italy had then afloat the powerful armor-clad *Duilio*; and her sister ship, the *Dandolo*, was being pushed forward at Spezia. These are iron ships, each 10,400 tons, of the *Inflexible* type, having turrets placed in a similar position to those of the latter vessel, while the ends depend on subdivision and on an armored deck for protection from fatal damage. The Italian vessels were commenced before the *Inflexible*, and, therefore, cannot in any way be said to have been copies of the English ship. In them external armor is placed on a citadel 107 ft. in length and descending for about 6 ft. below the water-line. This central distance of 107 ft. is the only part of the ship's side which is protected by vertical exterior armor. A design based on these lines soon attracted hostile criticisms from Sir Edward Reed, who, during the construction of the vessels, expressed his opinion that they were exposed "beyond all doubt and question" to speedy destruction ; and that the Italians "were pursuing a totally wrong course likely to result in disaster." This may be said to have been preliminary to Sir Edward's now historic attack on the *Inflexible* design.

In spite of the strictures of our ex-Chief Constructor the Italians not only followed up their plan of design undaunted, refusing to put outside armor on the ends of their ships, but actually had the temerity to abandon outside protection altogether—a step which must have fairly taken their critic's breath away. The result is the *Italia* and

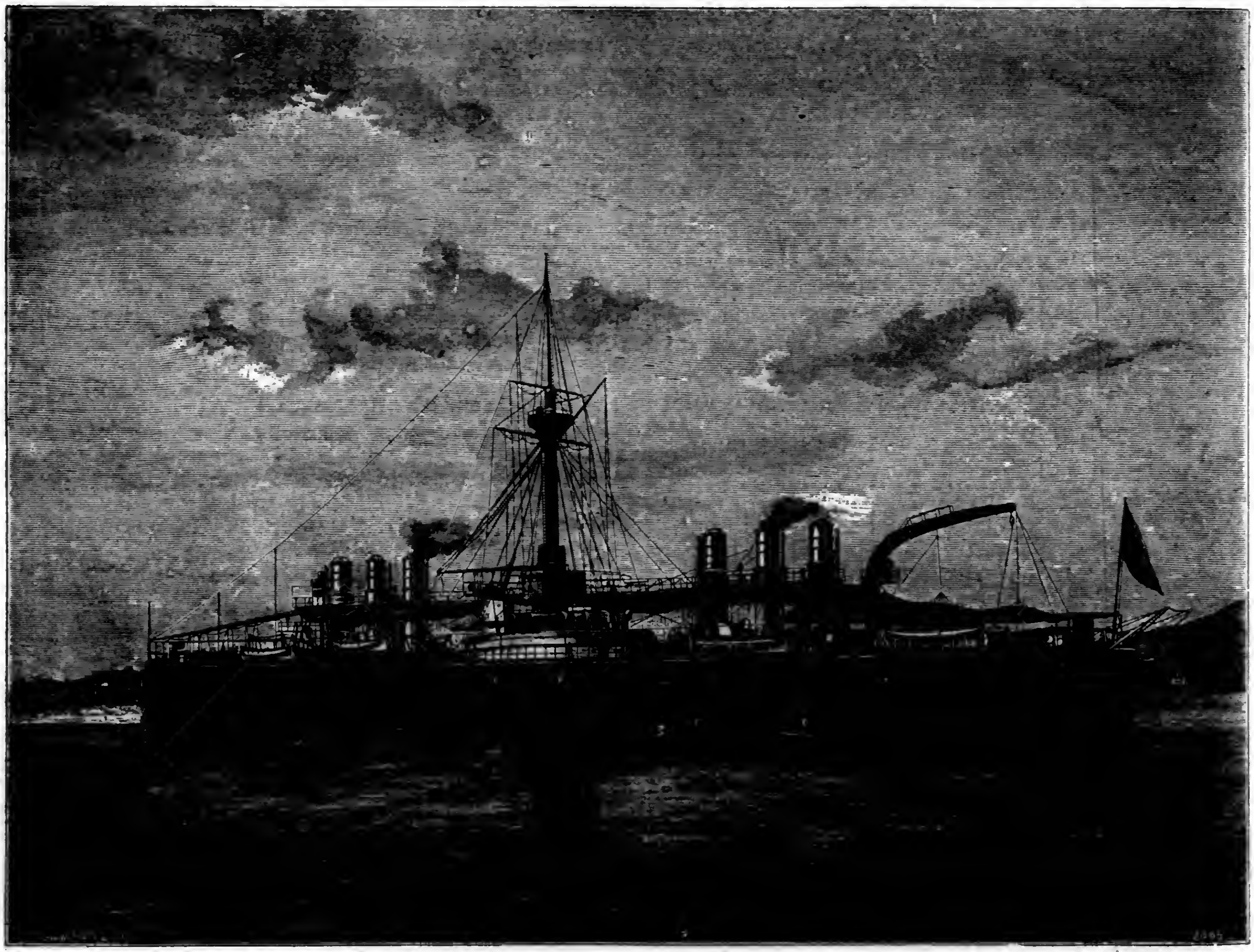
the wonderful ships of the same class which have followed her.

In view of the marvelously rapid progress made in the science of warship construction, the above facts may be looked on by some as quite ancient history, but however that may be, they are pregnant with interest to us at the present day. There are now in progress the two largest and most costly ships that have ever been added to the British Navy. We refer of course to the *Nile* and *Trafalgar.* These vessels are, in the opinion of some of our highest authorities, a distinctly retrograde step: and it is a pretty well acknowledged fact that had the constructive department at Whitehall had their own way, we should now be waiting for the advent of two costly war vessels far more nearly resembling the Italian soft-shelled mammoths than the extensively outside-plated ships in progress, if, indeed, we should not already have been in possession of such engines of warfare.

Had the counsels of Sir Nathaniel Barnaby and those who acted with him been allowed to prevail, there is no doubt but that some of the most important elements of warship design would have been immensely strengthened, and, on the other hand, there is no less doubt that a great sacrifice would have been made to secure these desirable points. Which way the balance of advantages would have turned, it is not our purpose now to consider, although we may perhaps at a future day return to the subject with a view of putting before our readers some of the more salient facts bearing on the question. In the meantime we append the leading features in the design of the *Italia*, which our readers may compare with those of the English ships. It should be remembered, however, that the *Italia* by no means represents the most matured schemes of her talented designer, the *Re Umberto* and the *Sicilia* possessing features that render them an advance upon the first great realization of an internally protected battle-ship.

The following are some of the particulars of design of the *Italia* and the *Lepanto*:

	Ft.	In.
Length between perpendiculars	400	6
Breadth of beam at water-line	73	9
" " upper deck	65	6
Draft of water forward	26	6
" " aft	30	6
" " mean	28	0
Area of immersed midship section	1,770 sq. ft.	
Displacement at load draft	13,480 tons.	
	Ft.	In.
Length of armored tower on fore and aft line	88	6
Breadth of armored tower across ship (extreme)	72	6
Length of armored tower *per se*	96	0
Breadth " "	52	9
Distance of stem from armored tower	170	0
Thickness of side of tower, including armor	3	3
Thickness of armor on tower	1	9
" " breastwork	1	6
Height of center of heavy guns above water-line	32	8
Height of top of tower above water-line	30	0
" upper deck above water-line forward	25	0
Height of upper deck above water-line aft.	23	0
Height of upper deck above water-line amidships	22	6
Height between upper deck and battery deck	7	9
Height between battery and second deck	7	9
Height between second and armored deck.	7	6
Depth of lower deck below water-line amidships at sides	5	6



THE ITALIAN WARSHIP "ITALIA."

Depth of hold under lower deck	21	0
Extension of ram beyond forward perpendicular	6	4
Distance of point of ram below water-line.	8	6

MACHINERY.

Number of engines	4 sets.
" cylinders	12
" propellers	2
Diameter of "	19 6
Number of boilers	26
" furnaces (three to each boiler)	78
Total grate area	1,521 sq. ft.
Length of ship fore and aft occupied by engines, coal, and boilers	250 0

The estimated weights of the hull, armor, etc., were given approximately as follows :

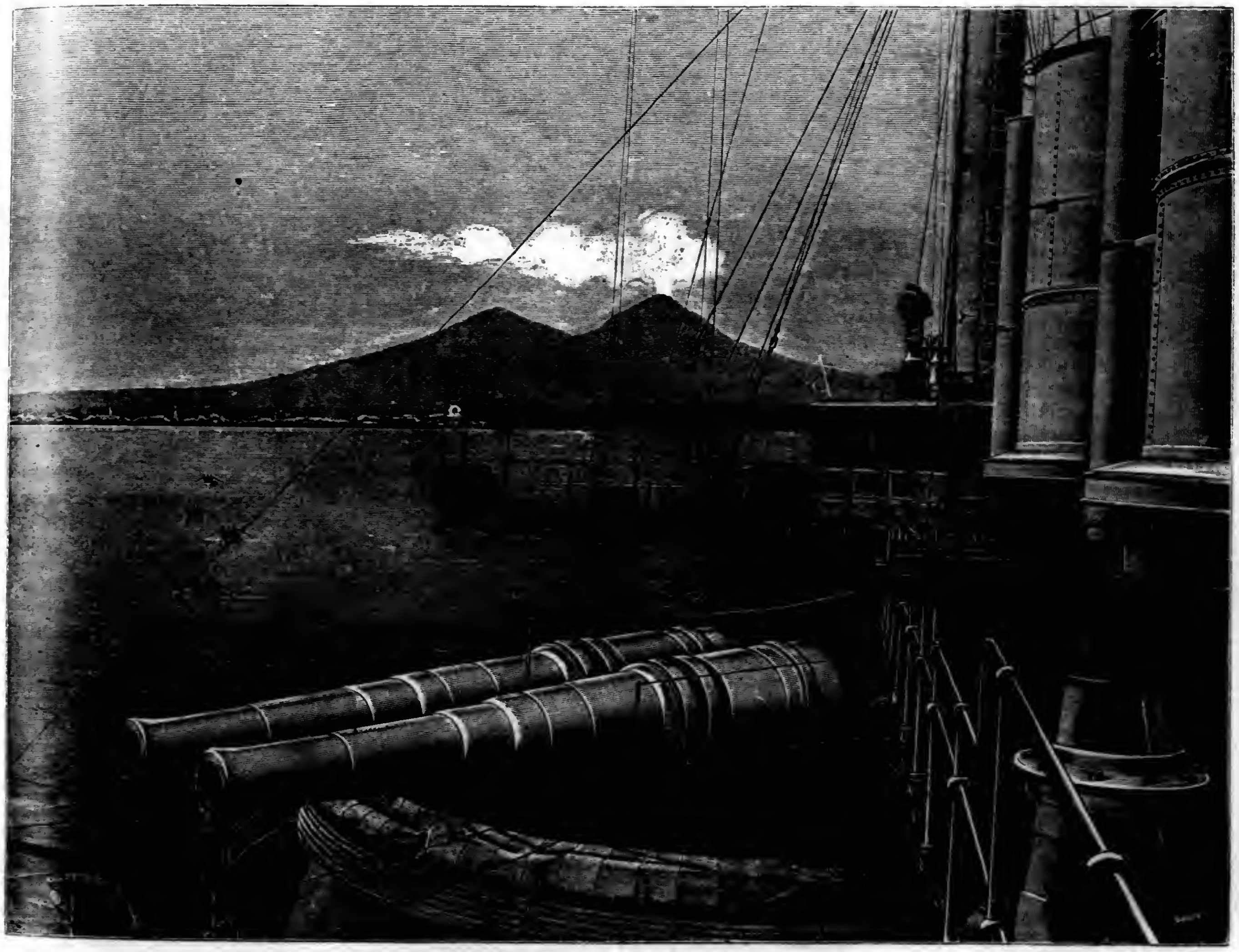
	Tons.
Hull	5,000
Armor of armored deck	1,200
" citadel	900
" ammunition shaft	246
" chimneys	552
Total weight of armor	2,898
Teak backing	114
The total weight of the machinery is about	2,200

The armament consists of four 43-cm. (100 ton) B. L. R. guns supplied by Armstrongs. There are eight 15-cm. (6-in.) Armstrong breech-loaders. Six of these are carried on the upper deck, two being respectively bow and stern chasers. There are six smaller quick-firing guns of 57 mm. caliber.

There are machine guns comprising 22 Hotchkiss and quick-firing guns for the boats and landing parties. There will also be a number of Maxim guns.

There are four torpedo ports arranged on the broadside, two ahead and two astern.

The two sets of engines for driving each of the *Italia's* twin screws have each three cylinders of equal size arranged in line on the shafting. At full speed they all take steam direct from the boiler, but in ordinary working the foremost cylinder of each set alone takes steam from the boiler, and exhausts into the other two cylinders. There are thus six cylinders to each propeller. The engines are placed amidships, the boilers being placed 14 before and 12 abaft them. The shafting runs under the after boilers. It is this unusual arrangement of the boilers which gives the vessel the somewhat peculiar appearance due to the position of the six chimneys, which it will be seen by the engraving are placed in two groups of three each before and abaft the barbettes. The latter are placed *en échelon*,



THE WARSHIP "ITALIA"—TOP OF CASEMATE.

and each one carries two of the monster 100-ton guns. The barbettes are contained in an armored casemate, which is supported by the unarmored structure of the ship, a point in design that has raised many adverse comments from naval critics in this country. The space thus enclosed is entered from below through an armored shaft, which leads below water to the space between the forward and after sets of engines. This armored tube serves as an ammunition shaft. The bases of the chimneys in each group are also protected by armored belts. The plated deck completes the armored protection of the ship. This deck extends from stem to stern, the armor being of steel, and 3 in. thick. The body plan of the ship shows this deck in a uniform curve extending from side to side. Where it springs from the skin of the vessel it is about 5 ft. 6 in. below water-line, and at its highest part it is about 1 ft. 6 in. below the level of the water. These figures are those which were allowed for in the design, but we believe, as a matter of practice, the *Italia*, like so many other war-

ships, has accumulated weight during construction, so that the deck is more submerged still. It is this under-water arrangement of the armored deck that has been so unfavorably criticised, and it may be noted that in the succeeding ships, *Re Umberto*, *Sicilia*, and *Sardegna*, the crown of the deck has been raised considerably above the water level, so as to conform more nearly to the arrangement followed in our own smaller protected ships of the *Mersey* type.

Steel is largely used in the construction of this vessel, and when we remember that she was commenced 10 years ago, we feel we have another reason to admire the courage and prescience of her designer. The bottom is sheathed with wood. The double bottom has 3 ft. 3 in. between the two skins in the midship part. There are two longitudinal water-tight bulkheads, extending fore and aft for 254 ft. Altogether the hull is divided into 53 vertical divisions, these being split up again horizontally by the four decks. Cork stuffing is extensively used in the side compartments. Six feet above the water-line is a deck of ordinary plating covered with wood ; and above this is the battery deck, having a height of 14 ft. above the water-line. Again, 7 ft. 9 in. above this is the upper deck, which supports the casemate containing the big guns mounted *en barbette*. The great height at which the *Italia* carries her guns is a very strong point in favor of her design, such an element being to a warship of the present day, when armored decks form so important an element of defense, very much what length of reach is to a boxer. High speed is another, and perhaps the most important advantage that was aimed at as a counterbalancing advantage in dispensing with side armor. The under-water shape of the *Italia* is very beautiful, and in looking at her model one is forcibly reminded of a remark of our present Director of Naval Construction, Mr. W. H. White, that however unsightly modern warships are to view afloat, some of the most beautiful forms ever produced by the naval architect were hidden from sight below the water-line of the ungainly superstructures. It was hoped that the *Italia* would steam 18 knots, and this was all but got on her trial, the speed, we believe, that was registered being as stated 17.8 knots. The power developed by the engines was considerably short of the contract. It was expected to get 18,000 indicated H.P., but there was a very large falling off from this. There was, it is said, a difficulty in getting air down to the furnaces, and the necessary amount of coal could not be burned. Alterations and improvements are now in course of consideration, and no doubt will lead to an increase in the power developed.

The *Lepanto* has made a satisfactory preliminary trial and has also made a successful run at sea. The full-power trial of this ship has not yet taken place. The *Italia* left Spezia recently to join the Italian fleet at Maddelena.

FURNACES FOR BURNING LIQUID FUEL.

A SERIES of papers by Herr Busley, of Kiel, a marine engineer, on Furnaces for Burning Liquid Fuel, appeared recently in the *Wochenschrift des Vereines Deutscher*. We present below, in a condensed form, the substance of these articles on a subject which is just now attracting much attention. The accompanying engravings are not intended to be complete drawings, but are simply sketches, indicating to the eye the general form of each device.

Herr Busley divides the plans for using liquid fuel into three classes, as the oil is used in a liquid, a steaming, or a vaporous condition. These classes he describes as : 1. Hearth fires. 2. Gas fires. 3. Spray fires.

As the number of appliances for using petroleum has been very great, the aim has been under each class to refer only to those of a leading or typical character.

I. HEARTH FIRES.

Under this class are included all those methods in which the design is to place or pour the liquid fuel directly in a fire-box, with an equal distribution, in order to secure complete combustion. This class is subdivided into : 1. Pan fires. 2. Step fires. 3. Drip fires. 4. Oozing fires.

1. *Pan fires* are the simplest and most primitive form of burning liquid fuel. In some of the works in the Baku petroleum district in Russia the waste or residuum from the refineries is put into the fire-box of a boiler in flat bowls. At others it is allowed to run into the fire-box on stones, or on the fire-bars, where it burns as best it may.

Biddle's method, shown in fig. 1, was specially intended for marine boilers, and was tried about 1862. There was a cast-iron fire-box made in one piece and closed at the bottom. The bottom had grooves radiating from the

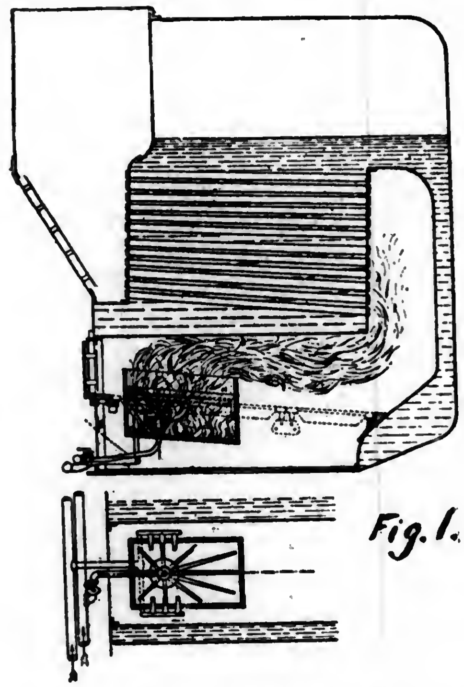


Fig. 1.

center, to insure the distribution of the oil. A storage tank above the boiler holds the oil, and a pipe from this tank carries it down, branch pipes leading to each furnace. These branch pipes are surrounded, at the point where they enter the fire-box, by an iron basket filled with red-hot coal, which sets the oil on fire. Air is admitted through small openings near the top of the furnace, by either natural or forced draft. This apparatus never came into general use.

The trouble with all pan fires has been that it is almost impossible to get a sufficient supply of air, and consequently the combustion is imperfect and is accompanied by a great deal of smoke.

2. *Step fires* are among the oldest devices in use. The most prominent systems are those used by Nobel, and by Ostberg in Sweden, in making his Mitis castings. This system consists of a series of iron troughs arranged in the shape of steps. The oil enters the topmost trough, and then overflows into the others, until it is all burned. Nobel introduced an air current to insure perfect combustion, but Ostberg asserts that this object is attained by a special chimney construction, and that he has succeeded in getting so high a temperature that he can melt iron at a distance of nearly 12 in. from the heating surface. It is further claimed that Ostberg, by the use of this furnace, has made 11 heats or castings in 12 hours.

Step fires are better than pan fires, because air can be admitted from both sides, and because, also, the mass of liquid fuel is much thinner than in pan fires, and better combustion can be attained. For marine engines, however, they are impracticable, as the rolling of a vessel makes the regulation of the quantity of oil that should overflow from one step to the other impossible.

3. *Drip fires* were first tried in 1865, and a system invented by M. Audouin (fig. 2) was shown at the Paris Exposition of 1867. M. Audouin, who was a gas engineer, attached particular importance to the use of the heavy tar oils, and placed a pipe of pottery-ware, from 30 to 40 in. long, in the grate, with a view to keep up a sufficiently high temperature to disperse and consume the oil. In place of a door to the fire-box, a plate was attached, to

which were affixed at the top and in the center rows of small iron pipes. Each pipe had a tap, and could be cut off from the supply pipe leading from the oil tank. To the mouths of the pipes a vertical groove was fitted, down which the ignited oil was conducted. In the case of sta-

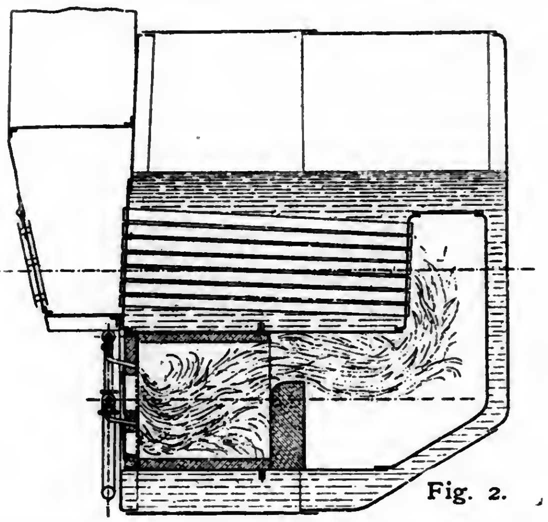


Fig. 2.

tionary boilers, Audouin allowed the oil to flow from the supply pipe in a canal along the plate, from which it overflowed into the vertical grooves. This, of course, necessitates only one supply pipe and one regulating tap. The plate that takes the place of the door has openings 0.2 in. wide between the grooves for admission of air. The air supply is regulated by a valve, movable in sections, and fitted in front of the openings. The chimney draft is equal to an air pressure that would raise a column of water 0.39 in., and Audouin claims to have evaporated about 28.6 to 33 lbs. of water with 2.2 lbs. of heavy tar oil in a longitudinal boiler walled in, with internal firing and a wheel draft, which did a duty of about 20 H.P.

Drip fires invented by MM. St. Claire-Deville and Dupuy de Lome, whose plans were based on the system of Audouin, were applied in 1868 to the boilers (fig. 3) of the imperial yacht *Puebla*, the fire-door and fire-bars of which were taken away. A plate of cast iron was fixed on the

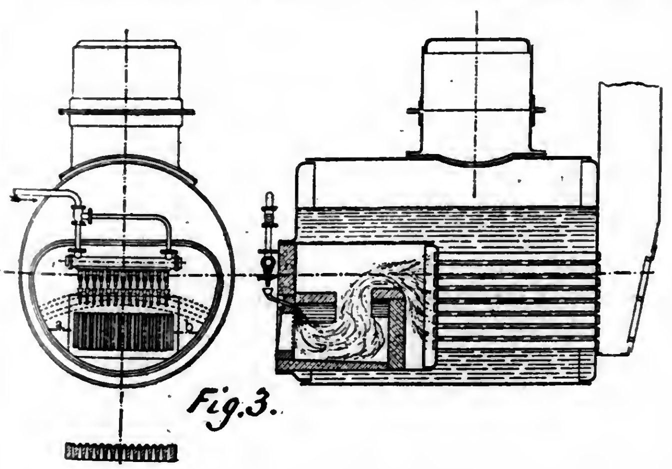
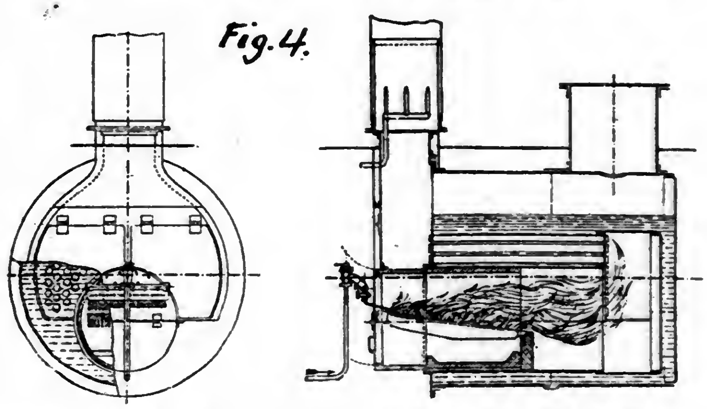


Fig. 3.

top, and vertical fire-bricks surrounded by a frame were fitted underneath instead. The upper frame of the plate received the mouths of 13 small pipes, each supplied with a funnel, and into these the oil fell in drops from a supply pipe. This supply pipe had a separate cut-off tap for each small pipe. The oil flowed into the supply pipe from a pipe, also provided with a tap, which was conducted from a tank placed so high as to insure a constant flow of oil. The taps regulated the supply of oil into the different pipes, and consequently its evaporation and distribution. The burning oil flowed out upon the floor of the grate, which inclined slightly backward and was made of fireproof stone, and was roofed over by the same material. The fire-bridge also had a vaulting of the same height. The space between the vaults allowed of the escape of the gases into the tubes. Heavy coal-tar oil, with a specific gravity of 1.044, was the fuel used. At the trial the flame was easily regulated by the taps. Air was admitted by means of valves, as in Audouin's system. A hand fan had to be used to start the fires with, as the low funnel of the yacht did not give sufficient draft; but when the engine was set in motion the exhaust puffed through the funnel, and caused sufficient draft. During the trial trips on the Seine in March and April, 1868, the engines indicated 65 H.P., and consumed 3.24 lbs. of oil per H.P. per hour; whereas they had only indicated 63 H.P. when coal was used, and had consumed 4.96 lbs. of coal per H.P. per hour. Experiments have since been made with this system on the locomotives of the Eastern Railroad of France, in which 1 lb. of oil evaporated 10.9 lbs. of water, while 1 lb. of briquette fuel evaporated 7.9 lbs. water. The inventor claimed that still better results could have been obtained in a specially constructed furnace.

The drip fires of Wagenknecht (fig. 4), which were made in 1870 and 1871 for Dwrient, at Dantzig, for some torpedo-boats, were chiefly based on Audouin's system. Their principal feature is really the arrangement of the hearth. The oil flowed out of the pipes into the grooves in the fire-bars, of which there were as many as there were

Fig. 4.



pipes; the oil was consumed in these grooves, and air was blown through the spaces from the unused ashpit, as it was found that the natural draft was not sufficient. The petroleum was contained in four tanks fitted behind the engine, which were connected by pipes, and a simple pump worked by the engine. At each revolution of the engine a certain quantity of petroleum was driven into the collecting-pipe in front of the fire-box. But notwithstanding the fans, the combustion was so imperfect that a constant column of thick black smoke came out of the funnel. A particular trouble was the trickling of the oil out of the fire-bars into the engine-room at each roll of the boats. Sometimes the fire went out altogether, owing to stoppage of the supply-pipe or other accidents. These torpedo-boats made about 7.46 knots with petroleum. As this system proved to be inefficient, the boilers were altered and adapted for coal-firing.

The drip fire of Kamenski, a variation of the Wagenknecht plan, was used in a stationary boiler at Baku in 1869, and on the steamer *Nasr-Eddin-Shah* in 1872. The results, however, were not satisfactory enough to secure its continued use.

In discussing the value of drip fires the author thinks that the distribution of the burning oil in separate grooves is a great advance on the pan and step systems, as by this method the admission of air is more easy. Nevertheless, the distribution and subdivision of the oil were not carried far enough on this system to insure perfect combustion. The comparatively successful results obtained by Audouin cannot be allowed to carry much weight, as walled-in boilers have such great advantages over marine boilers that the two cannot be compared. Audouin's practice of inserting a pipe of pottery-ware in the furnace was so successful, that it has been largely adopted by modern constructors; especially as by this means coal-using boilers can be easily converted into oil users by removing the fire-bars, which can always be replaced. But the drip fires, although superior to pan and step fires, cannot be regarded as satisfactory. The number of pipes they necessitate

render them too complicated, and make them liable to get stopped up. They are also a source of much annoyance and even danger in rough weather at sea, as the oil is liable to overflow, and they cannot therefore be seriously regarded as practicable.

4. The *Oozing Furnace* of Richardson was patented in England in 1864, and experimented on at Chelsea and Woolwich by the inventor, largely assisted by the Admiralty. After three years a certain measure of success was attained, and illustrations of this method tried in February, 1867, are given in fig. 5. The bottom of the furnace is lined with ordinary burned slack lime which is even at the top, but has vaultings underneath. The oil is conducted into these vaultings from two tanks situated near the boiler; the supply pipe of each furnace has a separate tap

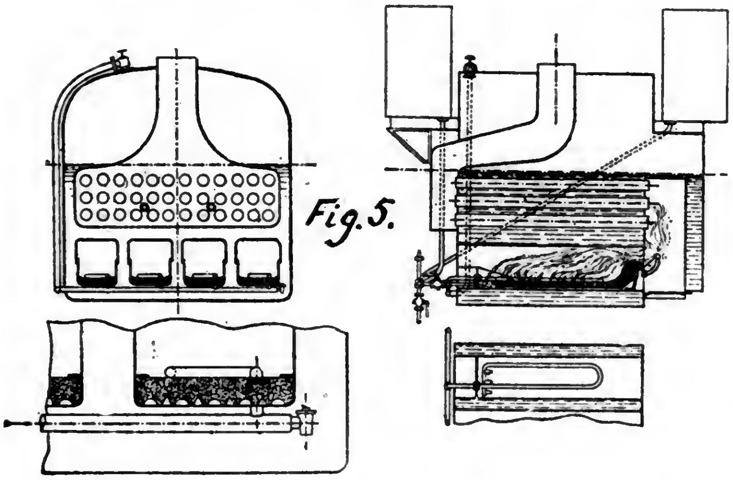


Fig. 5.

at the front wall of the boiler, side by side with the oil pipe; there is a steam pipe in the furnace, which, as is shown, passes twice along the upper portion of the stratum of lime for the purpose of superheating the steam it contains, and then delivers into the entrance place of the oil by means of three conical mouthpieces underneath the stratum of lime. The oil oozes up through the covering of lime, which serves as a sort of wick, and is ignited at once and consumed. The steam is used chiefly for the purpose of getting the necessary draft, but helps also to distribute the oil. Mr. Richardson's last experiments, made in 1867, showed much better results with unmixed than with mixed oils. The highest point attained was the evaporation of 16.76 and 19.66 lbs. of water to 1 lb. of oil. A favorable report was made to the Admiralty, but nothing further was done, chiefly because of the high price of oil in comparison with coal.

The oozing furnace of McKine was patented in the United States in 1865. The floor of the furnace is covered with a layer of sand; the door of the furnace is constructed to admit the air. The sand lies in a closed cast-iron box filled with water. The oil is under this, and traverses this box in a pipe, and enters the layer of sand through which it percolates. The water-box is intended to cool the oil. By means of a tank and pipes this water is removed and replaced by other water when it gets heated. This tank is near the boiler, and its bottom lies rather lower than the sand layer. A pipe leads from this tank into the oil space, and the water can, by turning a tap, be let into the latter, and thus the oil is forced up the pipe that leads it into the sand. It is claimed for this system that the oil used was consumed by a fairly short flame with a natural draft. It never came into extended use.

In Hayes's furnace, also an American invention, oil was allowed to run into the furnace on a layer of coal dust, small stones, etc.

The Patterson oozing furnace was tried in New Jersey about 1878, in a small vertical boiler; it was remarkable from the speed with which steam could be generated from cold water. It consisted of an iron tank, which was filled with asbestos. There were openings at the side of the tank, and the oil was introduced from below through a pipe, which was regulated by a tap. As soon as the asbestos had become saturated with oil it was lighted up, and the flames rose up out of the asbestos and the sides of the tank. Combustion could scarcely have been very perfect, as much black smoke was given off; but later a very high temperature was developed. The use of this system was, apparently, not extended.

The oozing furnace of Verstraet, patented in England about 1868, had a cup-shaped grate, filled with pumice-stone, which formed the percolating material for the oil.

Herr Busley thinks that oozing fires must be regarded as the most successful of the first class of furnaces for liquid fuel, as by means of the layer of porous material employed distribution of the fuel is secured. Nevertheless, perfect combustion cannot be insured for long. The oil is not able to burn off equally, but its lighter components are given off first, whereas the heavier constituents remain in the porous layer. As these heavy constituents of the oil accumulate in the porous layer, the lighter oils, continually supplied, find increasing difficulty in oozing through; and a period must arise when this porous layer becomes completely choked up. This period will arrive earlier in the case of the Richardson furnace, which is, after all, the best, as he employs heavier oils. Oozing furnaces have, owing to this disadvantage, fallen into disuse, notwithstanding the fact that they succeeded in attaining with ease a fourteenfold vaporization, whereas the drip grates did not reach a higher figure than tenfold.

II. GAS FIRES.

This class of furnaces is that in which the fuel is conducted to the furnace in a gaseous state. The number of devices of this kind is comparatively small.

The gas furnace of Shaw & Linton, which was patented in America as early as 1862, and intended for locomotives and marine engines, represents the transition from hearth furnaces to gas furnaces. As shown in fig. 6, the oil enters a reservoir in a tank in the furnace, and flows on to the fire-plate, which has been previously heated by a coal or wood fire. The lighter oils evaporate and enter the fire-box, where they are consumed. The unconsumed oil

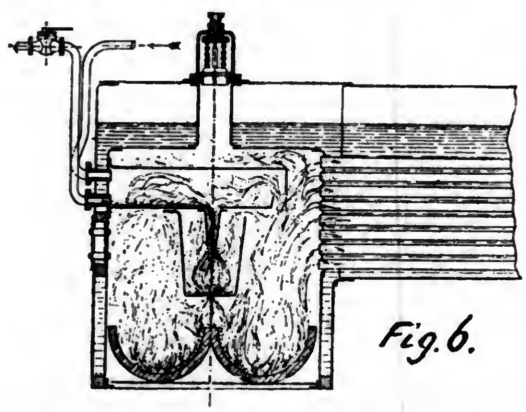


Fig. 6.

flows into a receptacle below, which is heated to greater temperature, and here the heavier oils are evaporated. The residuals that have survived so far are now conducted to the floor of the furnace, from which the fire-bars have been taken, and which is furnished with a cast-iron plate with indentations in it. Here the residuals are burned in the fire. Next to the oil supply pipe there is a pipe for the introduction of air. This system had this disadvantage, that the mass of oil-vapor was not always in consonance with the amount that could be consumed, and consequently, to avoid explosions, a safety-valve had to be provided for the escape of the gases that were in excess. During the trials of Shaw & Linton with a marine engine, the reservoir over the boiler was kept supplied from the tanks by means of a pump, and a steam jet into the furnaces increased the draft. To obtain this steam jet a subsidiary boiler was heated with anthracite before the generation of steam commenced in the main boiler. The trouble with this appears to have been the cost of operating.

The gas furnace of Mallet was patented in France, in 1864, but was intended for laboratories, and not much for boilers. Mallet heated the heavy oils and burned the vapor by means of strong currents of air, which created a very high temperature.

The Foote gas furnace, shown in fig. 7, was tried by the United States Navy Department on the gunboat *Palos* in 1867. This consisted of a cast-iron retort *A*, with a wrought-iron bottom riveted on, which can be fixed to any boiler grate after removal of the fire-bars. The petroleum is introduced into this retort by a pipe *B*, about $\frac{1}{8}$ in. in diameter; the vapor of the petroleum then streams out of burners through another set of pipes. The burners are

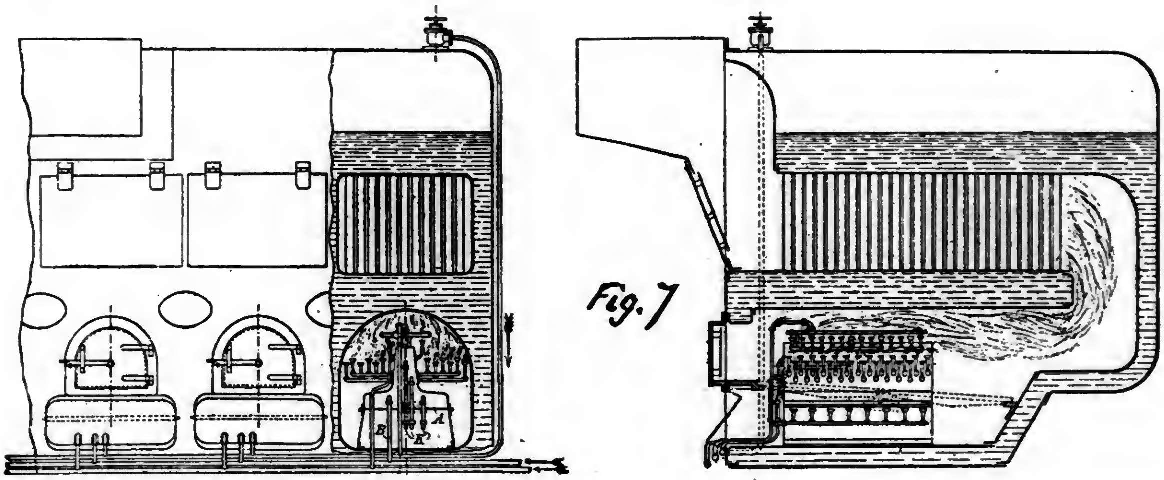


Fig. 7

arranged in rows on the bottom of the furnace. At the top of the retort a pipe containing steam, and another pipe leading from an air-pump, debouch. The pipes marked *K* convey the petroleum vapor to the burners under the retort. A wood fire is kindled on the floor of the retort, until the heat becomes so great that the petroleum entering it is at once volatilized. As soon as the gas begins to burn the wood fire is extinguished. The introduction of steam, air, and oil is regulated by valves in the pipes. In the trial trips it is claimed that in 9 hours 6,000 lbs. of water were evaporated by 279 lbs. of petroleum. The reason that nothing further was done with this system seems to have been that the retort, with the pipes and burners, required constant repairs and would not last, while the pipes were constantly becoming clogged up with the residuals.

The gas furnace of Dorsett & Blythe, shown in fig. 8, differed from that just described in the essential point that the gas to be burned was not made from the oil in the furnace itself, but in two small vertical boilers used as retorts and fired at first with a coal fire. These retorts

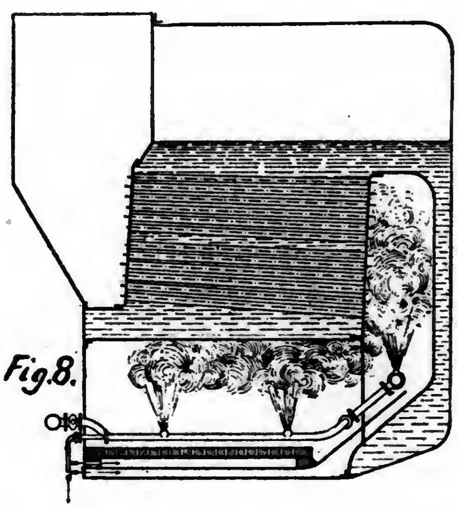


Fig. 8.

are not shown in the sketch. They were filled with a heavy tar oil, of 1.050 specific gravity, and the coal fire started. When the oil vapor reached a pressure of 20 lbs. it was conveyed to the furnaces of the retorts and entered a couple of burners, which continued the evaporation. When the oil vapor reached a pressure of 50 lbs., or a temperature of 500° Cent., it was let into the boiler furnaces. Each of these was closed with an ash-plate, and about 3 in. above this an iron plate was attached, which extended back as far as the combustion chamber. About 3 in. above this sheet again was another iron sheet, shorter and perforated, which was covered with fire-brick. The back opening between these sheets was completely closed with fire-brick, the front only partially so, and thus air could enter and find its way through the perforated sheet into the furnace. Air could also enter the combustion chamber between the lower iron sheet and the ash-plate; its admission was regulated by a sliding valve. The gas supply pipe went along the fire-brick to the combustion chamber and then back, and there was a connection from the rear bend to another pipe in the combustion chamber. These pipes were perforated with holes about 0.07 in. in diameter. The supply of gas was regulated by valves. Owing to the very high temperature of the oil vapor, the retorts and conducting pipes had to be surrounded by a sheet-iron casing filled in with sand. This apparatus was tried on the steamer *Retriever*, of 500 tons. During the trials the engines gave out 150 H.P., the fuel consumption being about 3.53 lbs. of oil per indicated H.P. per hour. The evaporation was at the rate of 12.35 lbs. of water to 1 lb. of oil. The combustion also is said to have been good, no smoke being given out. Somewhat later a furnace on the same plan was tried at Chatham, England, for heating armor-plates; in these experiments about 1 ton of oil was required where $2\frac{1}{2}$ tons of coal were generally used, and the time required for heating the plates was much less. This furnace, however, did not come into use, probably on account of its large first cost and the high cost of the oil compared with coal.

In relation to gas furnaces generally, Herr Busley's opinion is that they give better results than hearth fires. The distribution of the fuel and the subdivision by the use of burners was well carried out in both the plans described above. A sufficient supply of air and good combustion are easily secured. In fact, enough has been done to prove the efficiency of gas furnaces in point of performance. One of the disadvantages which have prevented their adoption is that they are complicated in construction, and consequently their first cost is high. Another disadvantage is that the temperature of oil vapor is about three times as high as that of steam at the same pressure, so that the retorts have to be made enormously strong, and even then are not safe.

But the chief fault of the gas furnaces is the rapid stopping up of the supply pipes, owing to the residuals not vaporizing. This caused suspension of working very rapidly in the case of the Dorsett as well as of the Foote furnace. These disadvantages have outweighed the few advantages gas furnaces possess over hearth fires, and have prevented them from coming into use, without reference at all to the question of the high working expenses during the present comparative state of prices.

(TO BE CONTINUED.)

LOCOMOTIVE BOILER EXPLOSIONS ON BRITISH RAILROADS.

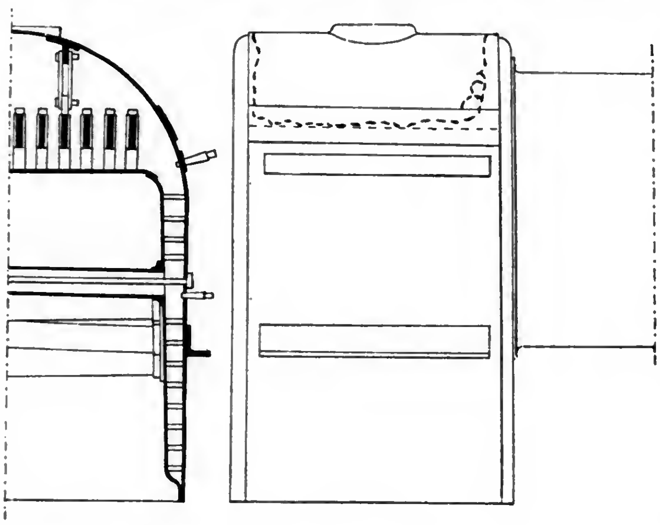
(*Concluded from page* 114.)

WE conclude below the series of condensed statements of the reports of the Inspectors of the British Board of Trade on accidents resulting from the explosion of locomotive boilers.

INSPECTORS' REPORTS.

February 13, 1884, the boiler of a shifting engine on the Great Western line exploded, the engine at the time standing on a siding in the Exeter yard. The driver had just before noticed water leaking from the outside fire-box, and went to call the shop foreman to look at it. Just as he returned the top-plate of the outer fire-box shell was blown off in two pieces; one, weighing about 600 lbs., struck the engine shed, 200 ft. away, while the other, weighing about 300 lbs., was thrown about 225 ft. Both these pieces were thrown off in the same direction, but a number of small pieces of the wooden lagging were thrown in the opposite direction, some of them falling 450 ft. away. The fireman was slightly scalded.

The engine had four wheels, all coupled, and a saddle tank. It was built in 1873; the boiler had a new set of tubes in 1880, and received general repairs in 1883. The boiler shell was of $\frac{7}{16}$-in. iron and had butt-joints with outside double-riveted strips or cover-plates, 7 in. wide and $\frac{9}{16}$ in. thick, the rivets being spaced 3 in. between centers. The inside fire-box was of copper, and had several cross-tubes connecting the water spaces on each side. The accompanying sketch shows a side view of the rear end of the boiler (the dotted lines showing the lines of



fracture) and a half cross-section of the fire-box, showing the crown-bars, braces, etc. The Inspector's comments on this explosion are as follows:

"It is seldom that so accurate a description of the manner in which a boiler exploded can be given as in this case, where the foreman fitter and the driver actually saw the exact spot where the plate commenced to give way.

"This spot was at the joint of the top-plate and the left-hand side-plate of the fire-box shell, and at a point about 18 in. from the back of the box.

"An examination of the boiler shows that at this point, and more or less all along the joint, there was an old flaw on the inside face of the butt-strip extending at some places through nearly a third of the thickness of the metal, and it is evident that the explosion was due to the weakness of this joint.

"The butt-strip at the corresponding joint on the other side is also flawed in a similar manner, but to a less degree; but the joint on the left side gave way first, the plate being then turned over, ripping up the transverse joints at each side, and breaking across on the right side of the safety-valve seat, along the line of bolts for the sling-stays.

"This form of joint is a bad one, as where there is only one butt-strip an unequal strain is thrown on the two sides of the metal, and any small flaw is very liable to develop to a dangerous extent. The metal of the boiler-plate itself was in good condition.

"There are in all 18 engines belonging to the great Western Railway Company with similar joints, the whole of them having been built for the Bristol & Exeter Railway Company between 1870 and 1875.

"They are being carefully examined, and one of the five already examined (the sister engine to this one) has a butt-strip flawed in a very similar manner. The Locomotive Superintendent informs me that he is strengthening the joints by removing the outside $\frac{9}{16}$-in. butt-strips and fitting instead two $\frac{7}{16}$-in. strips, one inside and the other outside, and that he has in the meantime largely reduced the working pressure on these engines.

"The boiler was last tested by hydraulic pressure up to 170 lbs. per square inch in March, 1880, and it is quite possible that if it had been again tested, when it was in the shops for extensive repairs in September, 1883, that the weakness in the joint which has now given way might have been detected."

July 5, 1884, the boiler of a freight engine on the North British Railway exploded at Balloch. The engine had just started after standing for some time on a siding, and the train had moved less than 600 ft. when the explosion took place. The boiler gave way along the top longitudinal joint of the plate behind the dome, the sheet turning over but not flying off. The explosion was not a violent one, and no damage was done to the engine. A man who was standing on the platform close to the track was fatally scalded, and two employés on the engine were slightly hurt. The engine had 17×24-in. cylinders and six 5-ft. drivers, all coupled. It was built in 1872, and had run in all about 290,000 miles. The boiler was of $\frac{7}{16}$-in. iron, the joints being lap joints. It received a new tube sheet and new set of tubes in 1880, and had been inspected (without removing the tubes) three months before. The usual working pressure was 130 lbs. The Inspector's statement and comments are as follows:

"An examination of the boiler of this engine shows clearly that it gave way along the longitudinal seam or joint at the top of the barrel, and that there was a groove or flaw of long standing throughout the whole length of this joint, which, from its position beneath the over-lap of the plate, could not possibly have been detected by any examination.

"The plate was in many places holding by a mere skin, and it is surprising that it had not given way sooner, but from its appearance I have very little doubt but that the flaw would have been detected if the boiler had been subjected to an hydraulic test when it was last in the shops for thorough repair.

"The usual examinations ordered to be made seem to have been properly carried out, and I do not think, therefore, that any fault is to be found with the servants of the company on this head, while there is no suspicion that the explosion was due to any tampering with the safety-valves, or to any neglect on the part of the driver or fireman.

"I am informed that all the new boilers of this company are now made with a better description of joint—a butt-joint with double cover-strips—and that for the last two years in every case when a boiler has been retubed it has been tested by hydraulic pressure.

"This is as it should be, but I would strongly recommend the company to have all the boilers of old pattern tested in this manner with as little delay as possible; and all boilers tested periodically.

"The metal of this boiler was originally of inferior quality, and has evidently deteriorated by use."

During the year 1883 only one boiler accident was reported, the collapse of a tube, by which one employé was slightly scalded. This did not require any special examination.

In 1884 there were four boiler accidents reported, in which one man was killed and four employés were injured.

Reports were made in two of these cases only, the others not being of sufficient importance to require investigation.

In 1885 there were no accidents of any kind resulting from the failure of boilers or parts of boilers reported. This was the first year since the reports began in which such a statement could be made.

In 1886 only one boiler accident was reported, in which two employés were hurt. This was of too slight a nature to require investigation, apparently, as no report was made upon it.

During the first half of 1887 there were no boiler accidents reported. The report for the second half of that year has not yet been published.

The first apparent general lesson to be drawn from a study of this series of reports is that, as a rule, boilers explode simply because they are not strong enough to stand the pressure, and not from any mysterious cause. In every case investigation shows either faulty construction, defective material, or weakening from corrosion ; or else excessive pressure or low water.

Another fact which the Inspectors have been careful to draw attention to is, that in a great majority of cases the explosions could have been prevented had the boilers been frequently and carefully inspected, and this is, perhaps, the best moral to be drawn.

Railroad Accidents in Iowa.

THE report of the Iowa Railroad Commissioners for the year ending June 30, 1887, gives the number of accidents to persons on the railroads of that State during the year as follows :

	Killed.	Injured.	Total.
Passengers	8	28	36
Employés	59	354	413
Other persons	65	58	123
Total	132	440	572

The number killed is one more than in the previous year ; the number injured is five less.

The causes of these accidents are given as follows :

	Killed.	Injured.	Total.
Train accidents	10	49	59
Caught in frogs	3	..	3
Coupling cars	9	134	143
Falling from trains	23	39	62
In getting on or off trains	20	47	67
Overhead obstructions	..	5	5
At highway crossings	4	8	12
Stealing rides	9	9	18
Trespassing on track	24	10	34
Intoxicated	3	1	4
Suicides	2	..	2
Miscellaneous	25	138	163
Total	132	440	572

The Commissioners' comments upon the statements given above are as follows :

The three killed by being caught in frogs were one on the Chicago & Northwestern, one on the Sioux City & Pacific, and one on the Burlington, Cedar Rapids & Northern. The Chicago & Northwestern is using a full blocking of wood for its frogs, which is not satisfactory, and proposes to adopt the Edwards' foot-guard. The Commissioners are not informed of the safety appliances against this class of accidents used by the other roads named.

Nine persons were killed and 134 injured coupling cars. The Commissioners in former reports have called the attention of the Legislature to this subject ; as yet there has been no action by the State. The Master Car-Builders' Association has agreed upon couplers of the Janney type as in all respects more fully meeting the conditions of the automatic coupler than any other form. Confining the inventive talent of the country to this type of coupler will have the effect to perfect it, and it may not be unwise for the State and General Governments to enact some law requiring the adoption of this type of coupler on all new cars and on the renewal of old cars.

Since the creation of the Board in 1878 the number of persons killed and injured in coupling cars has been :

	Killed.	Injured.	Total.
1878	17	70	87
1879	14	55	69
1880	17	87	104
1881	20	64	84
1882	16	182	198
1883	16	98	114
1884	8	109	117
1885	18	174	192
1886	10	126	136
1887	9	134	143
Total, 10 years	145	1,099	1,244

The persons are nearly all employés whose duty compels them to go where these casualties cannot always be avoided. It is hoped that accidents from this cause may be materially lessened during the coming year, and that the time is not far distant when automatic couplers will be in general use and the recurrence of these accidents mainly avoided.

Twenty-three persons were killed and 39 injured falling from trains. The air-brake when applied to freight trains (which we think cannot long be delayed) will reduce greatly the number of accidents from this cause. We never expect any arrangement can be made to do away with the hand-brake, but cars can be so handled that much of the exposure required on top of trains can be avoided.

Twenty persons were killed and 47 injured getting on and off trains while in motion. As a rule this is the result of individual carelessness, and we can suggest no precaution that will prevent a repetition of these accidents.

Nine persons were killed and 9 injured stealing rides. There is undoubtedly something fascinating in riding on the trucks of a car, for the position certainly is far from comfortable, and the class that travel in that way have no motive generally other than to gratify a taste for vagrancy. The risk is voluntarily assumed, and no one but themselves is responsible for the result.

Twenty-four persons were killed and 10 injured while walking on the track. The reports of this Board, covering a period of 10 years, show that 277 persons have been killed and 178 injured while walking on track ; 61 per cent. of these accidents are fatal. We have never believed that the general public appreciated the fact that a railroad track is always and under all circumstances a place of danger and should never be used for foot travel except in crossing. Those persons most familiar with the running of trains are more liable to these accidents than others. We see every year additional reasons why walking on railroad tracks should be made by statute a penal offense, not especially for the benefit of the railroads, but for the safety of the public.

The New Bombay Water-Works.

(From *Indian Engineering.*)

THE works of the Tansa project for the additional water-supply of the City of Bombay are now in full progress. The lake of supply, situated about 60 miles from Bombay, is to be formed by the construction of a rubble masonry dam across the valley of the Tansa. The length of this dam is 9,000 ft., and its greatest height, across the bed of the river, is 118 ft. This is the height to which it is to be built at present, but the section is so designed that it may hereafter, should additional storage be required, be raised to a height of 135 ft. The total estimated quantity of masonry in the dam, as at present being built, is 10,000,000 cubic feet. The portion across the bed of the river, where the width of the base is 100 ft., has now (January, 1888) been raised to a height of 41 ft. The masonry work is also in progress at different points on the north bank of the river, where the height is comparatively small, being between 40 and 50 ft. The total quantity of masonry executed up to date is 1,300,000 cubic feet. The average

daily number of masons now employed is over 350. The supplying of materials to this number of masons involves arrangements of considerable magnitude, and the total number of hands employed in connection with the dam works average about 4,000 daily. Numerous quarries have been opened in the neighborhood of the dam, and tramways have been laid from them to the site of the works. The lime used is obtained from kunker brought principally from the Nasik districts above the ghâts, a distance of some 40 miles from the works. The sand is obtained from the beds of rivers in the surrounding districts, and it is now brought from an average distance of about 7 miles. As the work progresses this distance will increase, as the sand nearer to hand is used up. For the manufacture of the mortar 8 mortar-pans driven by steam power are in use, besides several edge stone mills, or *ghânis*, which are used for portions of the work detached from the present principal center of operations—namely, the portion of the dam across the bed of the river. The water required for the several operations connected with the work is supplied by two steam pumps (one on either bank of the river) from the lake formed by the water now impounded, and it is distributed all over the works by a system of pipes. The monthly outturn of masonry is now about 300,000 cubic feet. The contractors for this work are Glover & Co. The water is to be brought from Tansa to Ghâtkopar, a distance of 48 miles, by a duct consisting partly of tunnels through the hills, partly of a masonry conduit (cut and cover), and partly of 48-in. cast-iron pipes, or siphons, across the valleys. There are eight tunnels of various lengths aggregating 3 miles, the longest being 6,300 ft. The section of the tunnels is 9 by 6 ft., and the gradient is 6 in. per mile. There are 26 miles of conduits, having a section 7 ft. in width between the walls and 7 ft. in height to the springing of the arch. The gradient is 6 in. per mile. There are seven valleys crossed by 48-in. pipes giving an aggregate length of 19 miles. The hydraulic mean gradient of each line of pipes, or siphon, is 3.2 ft. per mile. Work is in progress at several points along this length of 48 miles and a fair start has been made. Nearly all the tunnel faces have been opened. The shorter tunnels are being driven by hand labor, and in the longer ones the drilling is done by compressed air machinery, the explosive used being dynamite. The excavations for the conduit are in progress, and masonry has been commenced at several points. The earthwork of the siphon tracks on which the 48-in. pipes are to be laid is well advanced, and the laying of the pipes of siphon No. 6, which is 11 miles long, has been commenced. This siphon crosses the Bassein Creek, which separates the island of Salsette from the main land. The place selected for the crossing is at a point where the creek is divided into three channels by islands. The main channel is 1,500 ft. wide, and the two smaller channels each 400 ft. wide. The 48-in. pipes are to be carried over these creeks on bridges of a uniform type.

The superstructure consists of spans 100 ft. long between centers, formed of a pair of lattice girders with cross-girders on which the pipes are laid. The superstructure is supported on abutments and piers, each consisting of a pair of cast-iron cylinders 5 ft. in diameter up to low water spring-tide level, and above that level 4 ft. in diameter. All the cylinders are carried down to rock, and some of them have to be sunk to a depth of 60 ft. under the bed of the creek. Each cylinder is to be filled with concrete, and each pair of cylinders forming an abutment or a pier is to be braced together with heavy wrought-iron bracing. The work of sinking the cylinders is in progress, and a considerable quantity of the material for the bridges is on the ground. The contractors for the whole of the duct works are Walsh, Lovett, Mitchell & Co. The delivery of the 48-in. pipes for the syphons is in full progress, and about 18,000 tons have been delivered. The total quantity of pipes required for the works is some 48,000 tons. The contractors for the pipes are Macfarlane, Strang & Co., of the Lochburn Iron Works, Glasgow.

The water reaches Ghâtkopar at 226 ft. above mean sea-level. From this point into Bombay, a distance of about 12 miles, the water will be brought in pipes, consisting of a 48-in. main for the greater part of the way, and afterward branching into mains of smaller sizes. The line for this portion has not yet been finally located, and the work has not been commenced. All the works have been designed by and are being carried out under the direction of Mr. W. Clerke, Chief Engineer.

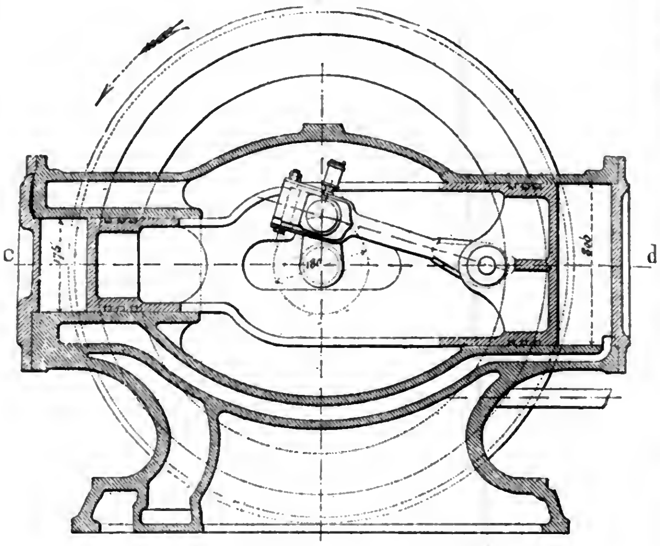
The Woolf Compound Engine.

(From the *Portefeuille Economique des Machines.*)

THE object which M. Mailliet has proposed in the design of the engine represented in the accompanying cuts is to make a machine, strong, simple, and occupying little room, but nevertheless able to develop considerable power. All the parts are simple and easily accessible.

The engine is formed by two direct-acting cylinders of different diameters, placed opposite each other on the

Fig. 1.



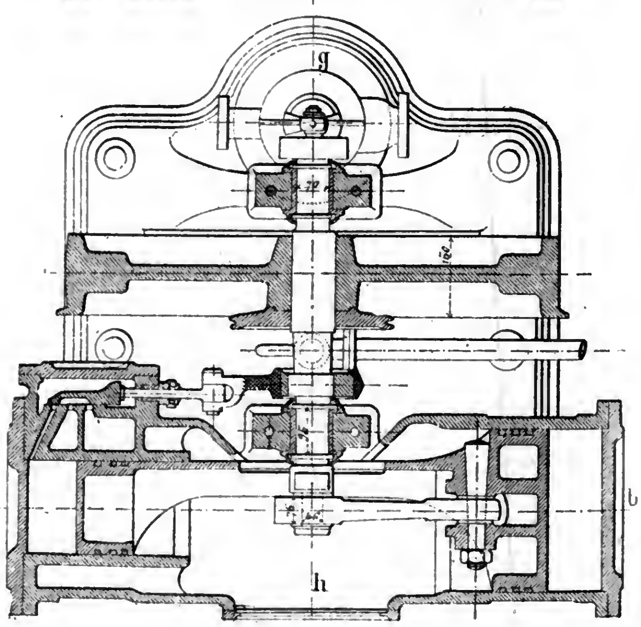


Fig. 2.

same axis, as shown in figs. 1 and 2. Of these cuts fig. 1 is a section and fig. 2 is a plan with section of the cylinders on the line *c d*, fig. 1.

The crank-shaft passes between the two cylinders and carries the driving pulley; this shaft can be provided with a second crank to work the condenser pump when it is desired to run the engine as a condensing engine.

The two pistons are formed by a single casting which carries at each end three rings which are pressed against the bore of the cylinder by six or eight little springs placed in grooves. There is no piston-rod, and the connecting-

rod is connected directly to the larger end of the piston, as shown.

The steam admitted in the small cylinder acts upon the piston, then passes into the large cylinder, where it acts upon the larger end of the piston, and completes its expansion.

The distribution of the steam is made in the small cylinder by means of a valve worked by an eccentric keyed

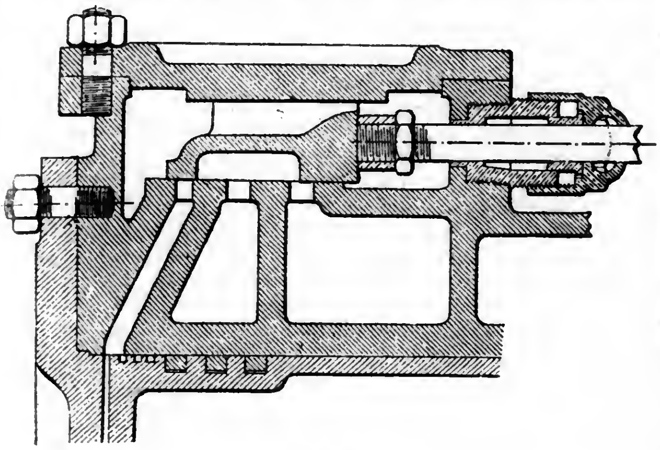


Fig. 3.

on the crank-shaft. Fig. 3 is a section of this valve on a larger scale.

The exhaust-port opens into a passage made in the large casting below the cylinders, through which it passes into the large cylinder. No valve is needed for distribution of steam in the large cylinder.

The machine is provided with a governor on the Damey system with horizontal axis and driven by centrifugal force. This governor is composed of two light, bell-shaped castings of bronze, as shown in fig. 4, which are so adjusted that while one enters the other there is little or no friction. They are joined by two elastic rods, each of which carries, at about the middle of its length, a cylindrical weight. One of the bell-shaped castings is corrugated, its surface forming three grooves of a shape suitable to receive the round belt by which the governor is driven from a pulley on the crank-shaft of the engine. The diameter of these

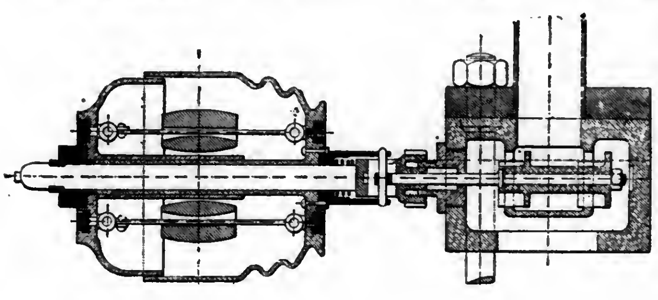


Fig. 4.

grooves is regulated to correspond with the different speeds of the engine. When the speed increases the weight of the elastic rods increases their distances from the center, causing the ends of the rods to approach each other. As one of the bell-shaped castings is fixed the other moves, drawing with it the rod of the steam valve which is attached to it. This valve is a piston valve with two seats so arranged that the least movement acts sensibly on the current of steam.

The use of this governor permits the employment of this engine to run dynamos used for electric lighting.

In actual use this engine is run at a speed of 175 to 200 revolutions a minute. The steam admitted with a pressure of 70 lbs. is expanded 4.3 times in the two cylinders. When the engine is run as a non-condensing engine the power developed is from 6 to 7 H.P.; it has been increased to 10 H.P. when the condenser is used.

This engine occupies a floor-space about 3 ft. 9 in. square, and it is about 3 ft. 4 in. in height.

The Indian Frontier Railroad.

(From the London *Engineering*.)

As the news from India is that the extension of railways on the northwestern frontier is still being proceeded with, we think it would be of interest to our readers to give them a brief summary of what has been done and of what is now in hand in Beluchistan and its frontier.

The policy of making our frontier unassailable, or at any rate as strong as possible, is one which should meet with the approval of all Englishmen; and it is a matter of regret that work of this description should have ever become the shuttlecock of party controversy, and that, in consequence, the work should have alternately been pushed on with feverish haste (with the concomitant waste of valuable lives and public treasure), or entirely abandoned, according as each political party was in office. It is to be hoped that the policy now inaugurated of quietly but surely making ourselves secure against invasion, and our frontier easily and quickly accessible from all parts of Hindostan, will be persevered with independently of the fluctuation of Conservative or Liberal majorities in Parliament.

The railway from the Indus near Sukkur toward Kandahar was originally called the Kandahar State Railway, until Mr. Gladstone's Government abandoned the above-named place, and it consists of several sections. The first, from Ruk Junction in Scinde to Sibi in Beluchistan, at the foot of the mountains, was laid in 1880, and is a level line across what is known as the "Put."

Sibi is at a level of about 400 ft. above the sea, while the Pishin plateau (on which Quetta is situated) averages 5,300 ft., the edge of the plateau on the Indian side varying in height from 5,800 ft. to 11,000 ft. On the northwest and north this plateau is bounded by mountains separating it from Afghanistan proper; the northwest range is called the Kwaja Amran, the mountains of which vary from 7,000 ft. to 9,000 ft. in height, while on the north the mountains have no particular name. On the west and southwest the plateau is bounded by an intricate mass of hills and deep ravines quite impracticable for any large body of men; for besides the geographical difficulties, the water obtainable is rendered unfit for drinking, being impregnated with magnesian and other salts.

From Sibi to the Pishin plateau two caravan routes have existed from time immemorial. One, the Bolan Valley or Pass, the entrance to which is about 20 miles southwest of Sibi; the other, the Hurnai Pass, the entrance being eight miles north of Sibi. Both these passes are the beds of rivers nearly dry at all ordinary times, but more or less flooded during the winter rains and in the monsoon season. The summit of the Bolan Pass is at a level of 5,800 ft., while that of the Hurnai is 6,600 ft. above sea level.

The Hurnai Pass was selected in 1880, being apparently the easier of the two routes for a railway, although subsequent surveys in 1885 show that this was a mistake, as the Bolan is not only the shorter route, but crosses the summit at a lower level, and would have been cheaper to build. In 1883, when Lord Ripon, then Viceroy, found that it was absolutely necessary to carry on the line toward the frontier, operations which had been abandoned in 1880 were resumed in the Hurnai Valley.

The construction of this second section was placed in the hands of Brigadier-General J. Browne, R.E. Few of the officers, and certainly not their Engineer-in-Chief, had had any previous experience in railway construction, so that it is almost unnecessary to state that the line cost at least 50 per cent. more than it should have done in competent hands. For this waste of public money General Browne and his staff are not so much to blame as the Public Works Minister, who specially selected the Engineer-in-Chief, and allowed him to choose his own staff.

This second section includes a line from Sibi to Quetta *via* Bostan Junction, 20 miles north of Quetta, and a line from Bostan Junction, westward to Killa Abdulla, at the foot of the Kojak Pass over the Kwaja Amran range. The ruling gradient between Sibi and Bostan Junction is 1 in

45, and between the junction and Killa Abdulla 1 in 100. The rails were linked through in this section in March, 1887, but the line is still far from complete.

In 1885, after the Penjdeh incident, when war seemed imminent, a temporary line on the 5 ft. 6 in. gauge was laid up the Bolan Pass to within 10 miles of the summit. This third section is laid on the bed of the river, and is liable to disruption by every flood. The remaining 10 miles, owing to the tortuous nature of the pass, were laid on the meter gauge. From the top of the pass to Quetta the line was continued on the broader gauge. This section was completed to Quetta in August, 1886, and the permanent way materials for all the upper portion of the second section as well as for an extension to Kandahar was delivered by it, thus materially expediting the completion of the second, or Hurnai section.

The 10 miles of meter gauge line on the Bolan are now being converted to the 5 ft. 6 in. gauge, with a ruling gradient of 1 in 25, laid with a central rack-rail on the Abt system.

During Lord Dufferin's visit to the frontier in November last, sanction was given to what may be called the fourth section of this railway—viz., from Killa Abdulla on the east side to Chaman on the west side of the Kwaja Amran by the route of the Kojak Pass. The summit of this pass is at a level of 7,200 ft. above the sea, but the railway will pass through at a lower level by a tunnel 2½ miles in length.

The many surveys made during the past three years conclusively prove that this route will be the shortest, quickest, and cheapest to construct. There will be a double line of rails, with a ruling gradient of 1 in 40, and the total length under 30 miles.

The last section, from Chaman to Kandahar, is 80 miles in length, over easy, undulating country, and can be quickly laid should occasion arise. Much has been said about the hostility of the tribes on the frontier, but so far it has been found that Ghilzais and Hazaras are flocking to the works, for they find it more profitable to get regular pay for work done than to pick up a precarious existence by raiding and robbery. Already, on that portion of the line which has been opened, a good traffic has sprung up, and the receipts from this frontier line show that at all events it will pay its working expenses, an event never anticipated when the line was originally projected.

The Navy and Coast Defenses.

SOME notes in relation to recent progress made in naval matters and to proposed additions to our coast defenses will be found below.

NAVAL MATTERS.

The Secretary of the Navy, in acting on the application of the Columbian Iron Works, of Baltimore, for the second payment on the gunboat *Petrel*, now in course of construction at their yards, granted the application, but deducted from the amount $500 as a penalty for failing to have the vessel completed within the contract time. This action is supposed to indicate the course which will be taken by the Navy Department in all cases where there is delay in completing work.

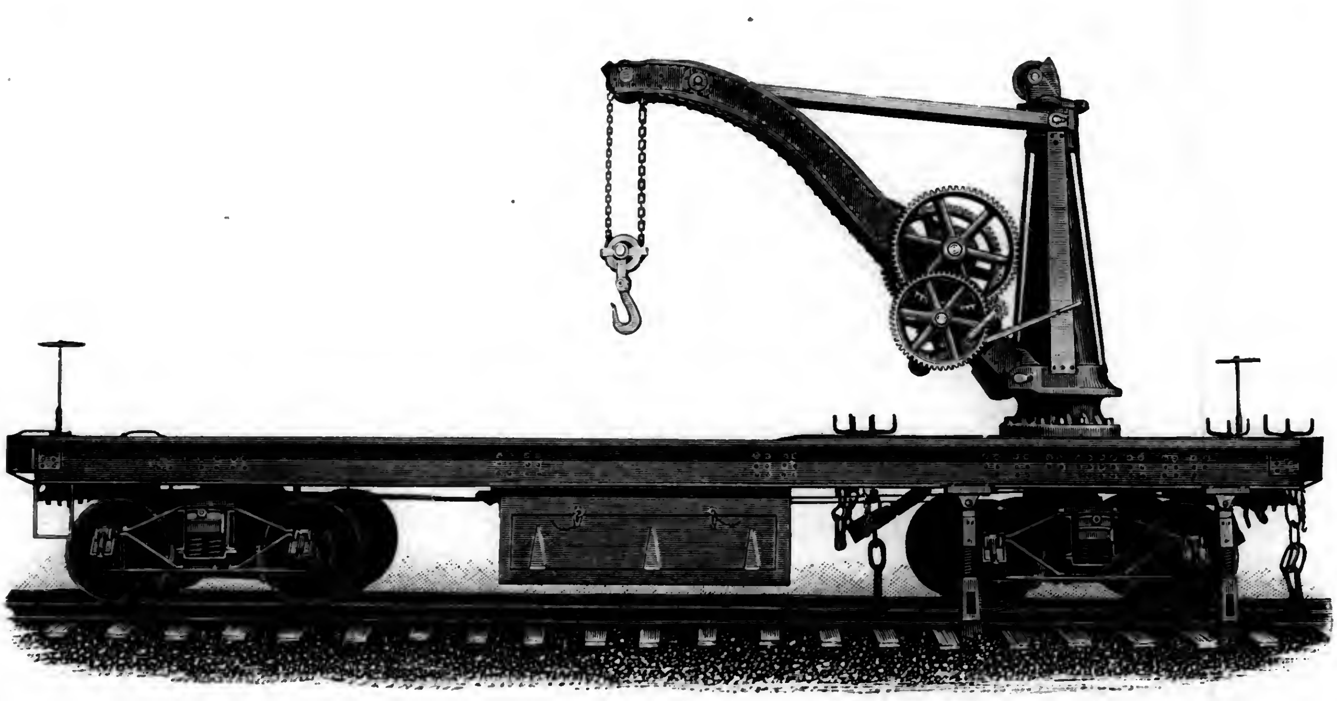
Messrs. Cramp & Sons have petitioned the Department for an extension of time on the gunboat *Yorktown* and the dynamite cruiser. They claim that the delay in these cases was due to frequent changes of the steel tests; as manufacturers who furnish material for these vessels would not go on with the work while the Board was considering changes to be made in the tests, fearing that their material would not comply with the amended requirements.

The 6-in. gun cast in Pittsburgh, to which reference was made last month, has been turned and bored without finding any flaws. It has been annealed, and will soon be shipped to Washington, where it will be finished and made ready for trial.

COAST DEFENSES.

The House Committee on Military Affairs has prepared a bill making appropriations amounting in all to $7,485,000, to be expended on coast defenses. The bill represents not only the views of the Committee, but also those of General S. V. Benet, Chief of Ordnance, with whom the Committee consulted frequently and carefully. The appropriations of the bill in detail are as follows:

Section 1 appropriates $500,000 for submarine mines and appliances for operating them, for continuing torpedo experiments, and for instructing the engineer troops in



NEW DERRICK CAR, PENNSYLVANIA RAILROAD.

details of torpedo service. It is understood that in the expenditure of this money the War Department will act in agreement with the Navy Department, which is now preparing the torpedo boats and appliances for the same service.

Section 2 appropriates $5,000,000 for the purchase of annealed steel for 8, 10, and 12-in. guns, the steel to be of quality and dimensions provided in specifications to be prepared, to be subject to inspection at any stage of manufacture, and to include the parts necessary to make complete guns of each caliber.

Section 3 appropriates $225,000 for the manufacture of breech-loading steel guns, carriages, and equipment for the service of batteries of field artillery. This section will provide for a pressing want, as none of the present field batteries are supplied with guns and carriages of the latest construction.

Section 5 appropriates $500,000 for the necessary expenses of materials and tests required to establish standard types of construction for guns and carriages; also for other necessary expenses of tests.

Section 6 appropriates $760,000 for building tools and fixtures necessary to complete the factory for heavy guns at the Watervliet Arsenal at West Troy, N. Y., in accordance with the recommendations of the Gun Foundry Board.

The remaining sections provide that the guns authorized in this bill shall be manufactured at the Watervliet Arsenal, the material to be procured by contract; and also that the appropriations provided for shall be available until expended.

Pennsylvania Railroad Derrick Car.

THE accompanying illustration shows a new derrick or wrecking-car recently completed at the Altoona shops of the Pennsylvania Railroad. The car is built almost entirely of iron and is intended to have sufficient capacity for very heavy work in its line. The engraving shows very clearly the general design and plan of construction of the car, in which are included all the improvements suggested by long experience with cars of this class.

New English Naval Vessels.

(From the London *Engineering*.)

EXAMINING the naval estimates giving the shipbuilding programme for the year we are just entering upon, we find that after finishing the seven armored vessels now in progress, there will remain to complete the armored ships *Victoria*, *Sanspareil*, *Aurora*, *Nile*, and *Trafalgar*. No new armor-clads will be laid down in 1888-89, but the *Superb* and *Thunderer* will be re-engined and the latter will be rearmed. The following is a summary of the new vessels to be put in hand during the year, excluding the ships of the Australasian squadron.

Nine protected ships—viz., two first-class cruisers; one torpedo depot and torpedo carrying ship; two third-class cruisers, steel bottomed, and four sheathed and coppered. There will be fourteen unprotected ships—viz., two sloops of the *Buzzard* type; six gunboats, improved *Rattlers*; six torpedo gunboats, *Sharpshooters*, and a sailing brig for training boys. All are to be built in the dockyards, except a first-class cruiser, a third-class cruiser, and two composite gunboats.

The special squadron for service in Australasian waters will consist of five protected cruisers of new design and two *Sharpshooters*. These seven vessels will be given out to contract.

This Australasian squadron sprang out of the Colonial Conference held in London in 1887, when an agreement was entered into between the Home Government and the Colonial representatives. The mother country is to bear the cost of building, arming, and equipping the ships; while the Colonies will meet the charges of maintenance up to a maximum of £91,000 annually during peace, and in addition pay a sum of £35,000 annually for ten years as a contribution toward the cost of construction. The total cost of these ships will be between £800,000 and £900,000. The ships will be completed in two years. On the expiration of ten years the ships will become the exclusive property of the British Government.

The memorandum next enters into a description of the new designs, from which we extract some particulars.

The cruisers are dealt with first. We are told that the Board well considered all the ships of this class, British and foreign, built and building, and came to the conclusion that two vessels, to be called the *Blake* and *Blenheim*, shall be built of the following dimensions. They will surpass in speed, coal capacity, protection, and armament any ships of the same class yet designed.

Length	375 ft.
Breadth	65 "
Displacement (about)	9,000 tons.
Speed on measured mile with full coal supply	22 knots.
Speed at sea, continuous steaming	20 "

Radius of action:

At 10 knots, about	15,000 knots.
" 20 " "	3,000 "

The armament is provisionally as follows:

Two 9.2 in. (22 ton) bow and stern chasers.
Ten 6-in. (5 ton) quick-firers, broadside.
Eighteen 3-pounders, quick-firers.
Four torpedo tubes.

A protective steel deck will run throughout the length of the ship. It will have a maximum thickness of 6 in., which, it is said, will afford the same protection from the "direct blows of projectiles" as would a vertical plate of 12 in. thickness. The phrase is a little obscure. Does it mean "direct" blows on the deck? If so it would be interesting to know how the end is reached. The propelling engines will be of the "vertical triple-expansion" type; and, it is said, many new features will be introduced. Compared to previous cruisers these ships are of large displacement; but if they are contrasted to merchant vessels having speeds of 16 to 20 knots, they are of small size.

We next come to a very interesting vessel, the torpedo depot ship *Vulcan*, which is to replace the *Hecla*. Her principal dimensions will be:

Length	350 ft.
Breadth	58 "
Displacement (about)	6,600 tons.
Speed with full coal supply on measured mile	20 knots.
Speed with full coal supply at sea (continuous steaming)	18 "

Radius of action:

At 10 knots (about)	12,000 knots.
" 18 " "	3,000 "

Armament:

Eight 36-pounders, quick-firers.
Twelve 3-pounders "
Four to six torpedo tubes.

A protective steel deck will extend throughout the length of the ship. It will have a maximum thickness of 5 in., and a minimum thickness of 2½ in. Hydraulic power on a large scale will be provided throughout for lifting the boats and doing all kinds of work. The ship will be laid down at Portsmouth. She will be equipped with laboratory, workshop, and a powerful torpedo armament, a large supply of torpedoes, mines, etc. She will be capable of protecting herself against all except the largest classes of cruisers.

The third-class cruisers will be of two types. For distant service where docking accommodation does not exist, four vessels of the *Blanche* class will be wood-sheathed and coppered. Their dimensions are:

Length	220 ft.
Breadth	35 "
Displacement	1,600 tons.
Speed with full coal supply on measured mile	16½ knots.
Speed at sea, continuous steaming	15 "
Radius of action at 10 knots	3 500 "

Armament:

Six 36-pounders, quick-firers.
Four 3-pounders "
Two torpedo tubes.

A protective steel deck will extend throughout the length of the ship and have over vitals a maximum thickness of 2 in. and a minimum of 1 in. The engines will be of the vertical triple-expansion type with ordinary return tube boilers; twin screws will be adopted.

For service from a base such as the Channel or the Mediterranean, the third-class cruisers will not be sheathed and coppered. They will resemble the *Blanche* in armament and protection, etc., but will have higher speed. A modified locomotive type of boiler, such as fitted in the torpedo gunboats, will be used. A maximum speed of 19½ knots will be reached. The vessels will be 50 ft. longer than the *Blanche* class and of 200 tons greater displacement. Their coal endurance at 10 knots will be about 2,600 knots. . . . .

With regard to the gunboats of the *Magpie* class the memorandum points out that in view of the requirements of the nation, both in peace and war, it has been found necessary to replace the obsolete gunboats and ships now serving abroad. The Board, therefore, determined to build a limited number of gunboats of an exceptionally powerful type in order that they might be able to fulfil the necessary conditions. Nine additional gunboats have therefore been ordered. They are practically identical with the vessels of the *Pheasant* class; but in order to provide for the 4 per cent. "margin for contingencies" ordered by the Board, they have been made 1 ft. broader and about 50 tons greater displacement than the *Pheasant*.

It is estimated that the following is the amount of displacement tonnage which for the three years ending April, 1880, will be passed into the fleet ready for commission: 1887–88, 75,000; 1888–89, 77,000; 1889–90, 75,000. Of this tonnage the following amount belongs to Lord Northbrook's special programme: 1887–88, 21,800; 1888–89, 16,800; 1889–90, 21,500 tons.

The Engineers' Club.

A MEETING, composed of leading engineers of the various engineering societies residing in New York and vicinity, was held in the rooms of the American Society of Civil Engineers, on the evening of February 3, 1888, Dr. Thomas Egleston presiding.

Upon the unanimous vote of those present, as well as in accordance with the views of many who could not be present, but who sent letters expressive of the same desire, it was decided to organize a social club, with headquarters in New York, for the accommodation of resident and non-resident engineers in the several fields of professional work.

As the first step toward carrying out this decision, the following gentlemen were elected officers to organize the Club and hold office until the first annual meeting: President, James A. Burden; First Vice-President, H. R. Towne; Second Vice-President, J. C. Bayles; Secretary, David Williams; Board of Managers, B. S. Church, Edward Cooper, Thomas Egleston, W. G. Hamilton, J. F. Holloway, W. A. Perry, J. C. Platt, A. C. Rand, R. W. Raymond, F. S. Witherbee.

Mr. Towne, Vice-President, thereupon took the chair, and after full discussion in regard to the details of organization, the following recommendations were made to these officers as expressing the sense of the meeting:

That the name be "The Engineers' Club."

That persons residing in New York City, or within a radius of 150 miles, be received only as resident members.

That persons residing at any distance beyond the above-named limit may be received as non-resident members.

That the initiation fee for the first 250 members, whether resident or non-resident, be $50, and the annual dues for resident members be $35; for non-resident, $20; the year of the Club to begin January 1 and July 1.

That the clauses defining eligibility to membership in the Mining, Civil, and Mechanical Engineers' societies be accepted by the Membership Committee as defining the qualifications for club membership.

The following committees were appointed: On Membership, By-Laws, Incorporation, Library, Location.

As soon as the several committees have completed their work and are ready to report, a general meeting of all whose applications for admission have been favorably acted upon will be called, of which due notice will be given.

From present indications it is deemed probable that the Club will start with a membership of at least 300, and that its numbers will steadily increase in the future.

CATECHISM OF THE LOCOMOTIVE.

(Revised and enlarged.)

BY M. N. FORNEY.

(Continued from page 133.)

CHAPTER X.

THE BOILER ATTACHMENTS.

QUESTION 233.—*How is water supplied to the boiler to replace that which is converted into steam?*

Answer. It is forced into the boiler against the steam pressure by a force or feed pump, or by an instrument called an *injector.*

QUESTION 234. *How is a feed-pump constructed and what is the principle of its operation?*

Answer. The ordinary single-acting pump, fig. 137, used on locomotive and other steam-engines consists of a *pump-barrel, A A,* which is a cast-iron or brass cylinder in which a tight-

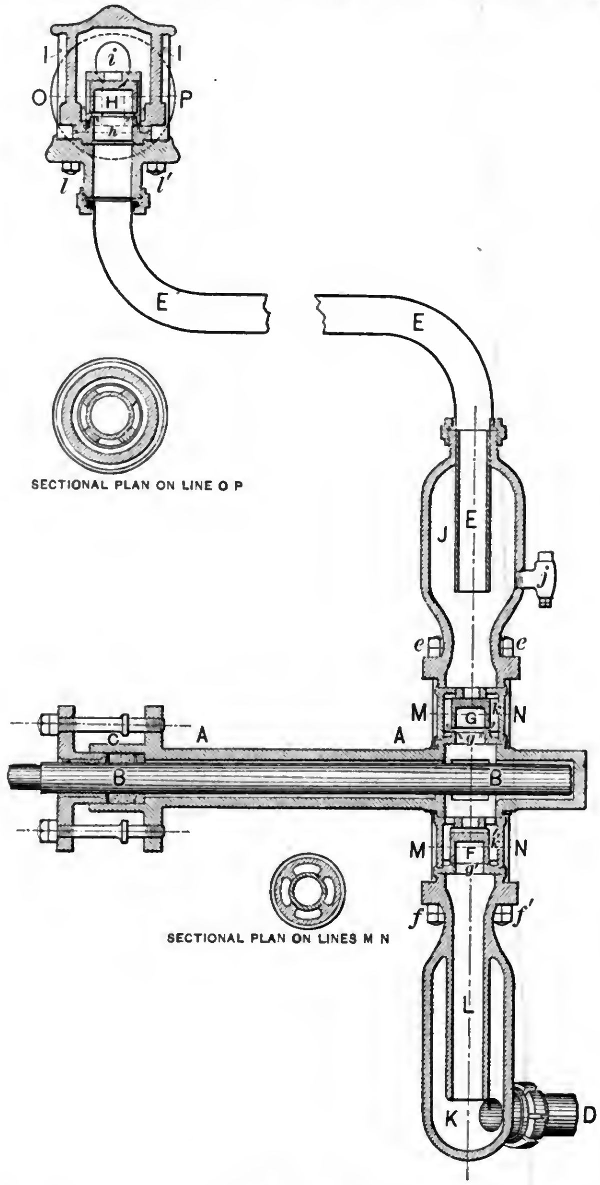


Fig. 137.

fitting piston, *B B,* called the *pump-plunger,* works. This piston or plunger is simply a round rod which works air-tight through a *stuffing-box, C,* the construction of which will be explained hereafter. The plunger is usually connected to the cross-head, and receives a reciprocating motion from it, but sometimes the plunger is worked by a small crank attached to one of the crank-pins or by an eccentric on one of the axles. The pump-barrel is connected with the water-tank of the tender by the *suction-pipe D* and with the water-space of the boiler by the feed-pipe *E.* Over the suction-pipe *D* is a valve, *F,* called

the *suction-valve*, which opens upward, and below the feed-pipe *E* is another valve, *G*, called the *pressure-valve*. These valves are cylindrical or of the form of an inverted cup. They are made of brass, and rest on brass seats, *g*, *g'*, to which they are fitted so as to be water-tight. They work in guides, *k*, *k*, called *cages*, the form of which is more clearly shown in the sectional plan, fig. 137. When the plunger is drawn out of the pump-cylinder it creates a vacuum behind it, and the pressure above the valve *G* closes it, while the atmospheric pressure on the water in the tank forces it into the suction-pipe *D*, opens the valve *F*, and fills the pump-cylinder. When the plunger is forced back again the force with which it presses against the water in the pump-barrel *A* closes the valve *F*, and lifts the pressure-valve *G*, and the water is then forced through the feed-pipe into the boiler. In order to be certain that the water in the boiler will not flow back into the pump, and also to prevent all the water and steam in the boiler from escaping in case of accident to either the feed-pipe or pump, another valve, *H*, fig. 137, called a *check-valve*, is placed between the feed-pipe and the boiler. The construction of this valve is similar to that of the pressure and suction valves. It is inclosed in a cast-iron or brass case, *I I*. All of these valves have cages or guides in which they work and which also act as stops, to prevent them from rising from their seats further than a certain distance. This distance is called their *lift*, and the successful working of the pumps depends very much on the amount of lift which the valves have. This is usually from $\frac{3}{16}$ to $\frac{1}{2}$ in. The valve *G* is represented open and the darts at *g* show the directions of the flow of the water. The valve *F* is closed.

Over the pressure-valve *G* is a chamber, *J*, called an air-chamber. When water is forced into this chamber, it is obvious that as soon as it rises above the mouth of the pipe *E*, the air above the surface of the water will be confined in this chamber. This confined air, being elastic, will be compressed and expanded by the pressure of the water, so that it forms a sort of cushion, which relieves the pump and the pipes from the sudden shocks to which they are subject, owing to the rapid motion of the pump-plunger.

Another air-chamber, *K*, is sometimes placed below the suction-valve *F*. The object of this is to supply a cushion to relieve the suction-pipe from the shock which is caused by the sudden arrest of the motion of the water in the pipe when the valve *F* is closed. When the pump-plunger is drawn out, the water flows through the valve *F* to fill the vacuum in the pump-barrel *A A*, and consequently all the water in the suction-pipe is put in motion. As soon as the plunger returns, the valve *F* is closed and the motion of the water is suddenly arrested, thus producing more or less of a shock in the pipe *D*. When the water in the air-chamber *K* rises above the mouth of the pipe *L*, it is evident that the air above that line will be confined in the space surrounding the pipe. This air then forms a cushion in the same way as that in the upper air-chamber *J* does, which has already been explained.

QUESTION 235. *How can the pump be taken apart and the valves examined?*

Answer. By removing the nuts *e*, *e*, by which the pump-barrel *A A* and the air-chamber *J* are held together, they can be taken apart, and the valve *G* and cage *k* can then be removed. In the same way, by removing the nuts *f f*, the lower chamber *k'* can be detached from *A A*, and the valve *F* and cage *k'* can be taken out. The check-valve *H* can be taken out by removing the nuts *l*, *l'*, which hold up the valve-seat *h* and also the valve and cage.

QUESTION 236. *To what risk is a check-valve like that shown in fig. 137, exposed?*

Answer. In case of a collision or other accident it may be broken off, and the hot water then escapes from the boiler, and is liable to scald persons who cannot escape from the wreck. In several instances many persons were scalded to death and others terribly injured in this way.

QUESTION 237. *How can the danger of such accidents be lessened?*

Answer. By putting the check-valve inside of the boiler instead of outside. Fig. 138 shows a check-valve of this kind. *A A* is the boiler plate and *B B* is a cast-iron flange cast in one piece with the valve-seat *C*. The flange is bolted or riveted to the outside of the boiler and the seat is let into the inside through an opening cut into the boiler plate. *D* is a flap-valve which covers the opening in the seat. Its position when open is indicated by the dotted lines. *F* is an elbow pipe screwed into the casting *B B*, and is connected with the pump or injector. In case of an accident, if this elbow pipe is broken the valve will still keep its opening closed and prevent the escape of the hot water from the boiler. This or some similar safeguard against the terrible accidents which sometimes result from injury to check-valves should be generally adopted.

QUESTION 238. *How can it be known whether the pump is forcing water into the boiler?*

Answer. To show this a cock, called a *pet-cock*, is attached to the upper air-chamber.* By opening this cock, if the pump is working, a strong jet of water will be discharged from it during the backward stroke of the pump-plunger. If the pump is not forcing water into the boiler, or is working imperfectly, the stream discharged from the pet-cock will be weak, and the

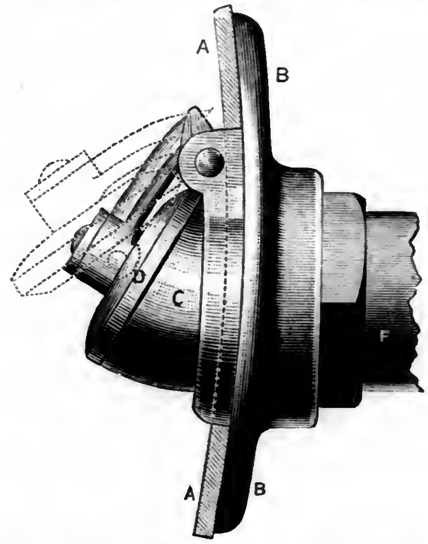


Fig. 138.

backward and forward strokes of the plunger will thus not be very definitely indicated by the discharge from the pet-cock.

Another small cock is often attached to the lower air-chamber, or to the feed-pipe, to allow the water to escape from the pump in cold weather, when the engine is not working, so as to prevent it from freezing.

QUESTION 239. *Why is it necessary to be able to regulate the quantity of water which is forced into the boiler by the pumps?*

Answer. Because when the engine is working hard—that is, pulling a heavy load up a grade, more steam and consequently more water are consumed than when it is not working so hard, and therefore more water must be forced in to supply the place of that which is used in the form of steam. If more water is forced in than is consumed, the water will rise and fill the steam-space, and a part of it will then be carried into the cylinders without being evaporated. If too little water is forced into the boiler, the heating surface will not be covered, and there will consequently be danger that those portions which are exposed to the fire will be overheated and injured.

QUESTION 240. *How is the supply of water which is fed into the boiler by the pump regulated?*

Answer. By a cock in the suction-pipe called a *feed-cock*, which can be regulated by the locomotive runner, so that more or less water is supplied to the pump. There is also a valve in the water-tank by which the supply of water can be regulated.

QUESTION 241. *On what part of the locomotive are the pumps usually placed?*

Answer. They are usually attached to the frames behind the cylinders, and are connected to the cross-head, as has been explained; but they are sometimes placed inside of the frames—that is, between the wheels, and worked from an eccentric on one of the axles, and sometimes they are placed outside of the wheels near the back part of the locomotive, and worked from short cranks attached to the crank-pins.

QUESTION 242. *What provision is made for preventing the water in the pumps from freezing in cold weather?*

Answer. Pipes which communicate with the steam-space of the boiler are attached to each of the suction-pipes, so that, by opening valves in the former, steam is admitted into the suction-pipes to heat the water in them.† By admitting this hot water into the pump, it is kept warm, and the water is thus prevented from freezing.

QUESTION 243. *What is an "injector"?*

Answer. It is an instrument in which a jet of steam imparts its velocity to water, and thus forces it into the boiler against the pressure of the steam.

QUESTION 244. *What are the principles of the action of an injector?*

Answer. The action of an injector is due to the fact that the velocity of steam which escapes from a boiler at a given pressure is very much greater than that of water under the same

* The pet-cock is sometimes attached to the feed-pipe.

† Injectors are now made so that steam can be admitted through them to the heater pipes.

conditions. If water is brought in contact with a jet of steam, the latter will impart its velocity to the water, and by mixing with it the steam will be condensed.

QUESTION 245. *How is an injector constructed?*

Answer. Fig. 139 represents an elementary form of an injector. *B* is a boiler and *W* a water-tank. *A* is a pipe to carry steam from the boiler to the injector, and *C* one for supplying it with water. and *D* another pipe to conduct the water to the boiler. The pipe *A* terminates in a nozzle, *F*. The pipe *C* terminates in a hollow cone, *E*, which surrounds the nozzle *F*. When steam is admitted to the pipe *A* by opening the valve *K*,

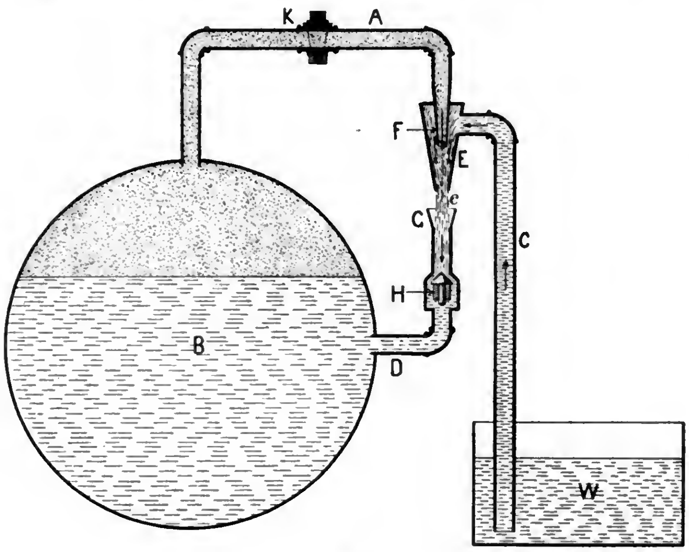


Fig. 139.

it escapes from the nozzle *F* and the lower end of *E*, and creates a partial vacuum in the cone *E* and in *C*. The water is thus sucked up from the tank *W*, and flows through the pipe *C* into *E*, where it meets the current of steam escaping from *F*. This carries part of the water with it, and they escape at *e*. Below *E* there is another tube, *G*, which is connected to the boiler by the pipe *D*, and has a valve, *H*, which is raised up by the pressure of the water in the pipe *D*, and it thus closes the lower end of *G* so that no water can escape from the boiler through the pipe *D*. It will be noticed that there is some space at *e* between the lower end of *E* and the top of *G*. When steam is admitted to *F*, as has been explained, it sucks the water up the pipe *C* and forces it out at *e*. When the stream of steam meets the water in *E* the steam imparts its velocity to the water, but in mixing with it the steam is condensed so that the jet, which escapes from *E*, is composed of water alone. This at first escapes from *e*, but after flowing a few seconds its velocity and momentum become so great that it forces the valve *H* down, and the jet of water then flows into the boiler, against the pressure of the steam. As soon as the injector ceases to work the check-valve *H* is closed by the pressure of the water below it, so that no water can escape from the boiler.

QUESTION 246. *How is the operation of the injector explained?*

Answer. The escaping steam from the nozzle *F* unites with the feed-water in the cone *E*, and gives to this water a velocity greater than it would have if escaping directly from the water-space in the boiler. The power of this water to enter the boiler comes from *its weight* moving at the *velocity* acquired from the steam, and it is thus enabled to overcome the boiler pressure.

This can be illustrated with a wooden ball, which will float on the surface of water and will require considerable force to make it sink, but if it is thrown violently into the water, it will sink to a considerable depth before its buoyancy will overcome its momentum, or *actual energy*. If, however, we were to take a cork or very light, hollow wooden or india-rubber ball, no matter how violently we throw it into the water, it will not sink, because the total *actual energy* of any body IS PROPORTIONAL TO ITS WEIGHT MULTIPLIED BY THE SQUARE OF ITS VELOCITY, and therefore if we throw the hollow ball at the same velocity as the solid one, the former will still have much less energy than the latter. Now, as already stated, steam under a given pressure escapes from an orifice with a very much greater velocity than water. But steam being very light, if its weight is multiplied by its velocity its total energy will be comparatively small. Now, in the injector, a portion of the high velocity of steam is imparted to the heavy water, because this water is presented to the action of the steam, not in a mass, as in the boiler, but in small quantity and in such a position that it can easily escape, so that it gradually acquires as high a velocity as the escaping steam can impart, and at the same time the steam is condensed, and therefore there is a heavy substance with a high velocity, whose actual energy is sufficient to overcome the pressure in the boiler. If the steam were not condensed we would have a comparatively light substance moving at a high velocity, which, as has already been explained, would have little actual energy, and would therefore not overcome the boiler pressure.

QUESTION 247. *Will the injector feed hot water?*

Answer. The instrument will not work when the feed-water is too hot to condense the steam, for the reasons given above, and the amount of water thrown is always the greatest when the feed-water is the coldest. Steam at a low pressure can be condensed more readily than steam of higher pressure, because it contains less heat. The feed-water may be used hotter to condense low steam than to condense high steam. In using the injector, the lower the boiler pressure the hotter may be the water within certain limits, the limit being the possible condensation of the steam.

QUESTION 248. *How are injectors for use in locomotives constructed?*

Answer. The simplest form of injector which is made is that shown in fig. 140, in which all details of construction are omitted. In this the nozzle *E*, called the *receiving-tube*, the cone *E*, called the *combining-tube*, and the pipe *G*, called the *delivery-tube*, are all fixed. In this the steam from the boiler, passing through the pipe *A*, enters the *receiving-tube F*. Here it is joined by the water which enters the pipe *C*. The water condenses the steam in the *combining-tube E*, and a water jet is formed which is driven across the *overflow* space *e e*, and enters the *delivery-tube G*, thence past the *check-valve H* into the boiler. During the passage of the water from *E* to *G*, as it passes across the *overflow* space *e e*, if too much water has been supplied to the steam, some will escape at this point and flow

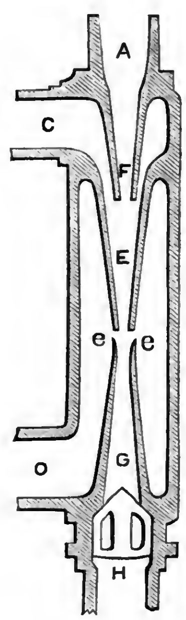


Fig. 140.

out through the *overflow nozzle O*, while if too little water has been supplied, air will be drawn in at *O*, and carried into the boiler with the water.

QUESTION 249. *Will a "fixed-nozzle" injector, such as has been described, answer as a boiler feeder on locomotives?*

Answer. It will answer at some one pressure of steam, to which pressure it may have been adapted in making the instrument, and at that pressure it will work admirably; but it will not work satisfactorily at any other pressure, either higher or lower, and has not much range in quantity of water delivered.

QUESTION 250. *What is required to make an injector work at different pressures?*

Answer. The instrument must be so made that the water passage between the receiving-tube and the combining-tube can be varied in size. This is usually done by making the combining and receiving tubes conical and moving the former to or from the latter, thus contracting or enlarging the water-space. Such adjustment must be made at each change of steam pressure in the boiler.

QUESTION 251. *Is it essential that injectors should be in a vertical position, as shown in figs.* 139 *and* 140?

Answer. No. Injectors will work equally well in any position. For convenience they are usually attached to locomotives, so that their axes or center lines stand horizontal.

QUESTION 252. *What different forms of injectors are used?*

Answer. A great variety of these instruments are made, only a few of which will be illustrated and described.

SELLERS' INJECTOR.

Figs. 141 and 142 represent an outside view and section of a self-acting injector manufactured by Messrs. William Sellers & Co. (Incorporated), of Philadelphia. It consists of a case, *A*, provided with a steam inlet, *B*, a water inlet, *C*, an outlet, *D*, through which the water is conveyed to the boiler, an overflow opening, *E*, a lever, *F*, by which to admit steam, start and stop its working, a hand wheel, *G*, to regulate the supply of water, and an eccentric lever, *H*, to close the waste-valve when it is desired to make a heater of the injector.

The operation of the injector is as follows: The water inlet *C* being in communication with the water-supply, the valve *a* is until the steam plug *i* is out of the forcing nozzle *K*, thus allowing the steam to pass through the forcing nozzle *K* and come in contact with the annular jet of water which is flowing into the combining-tube around the nozzle *K*. This jet of water has already considerable velocity, and the forcing steam jet imparts to it the necessary increase of velocity to enable it to open the valve *K* and thus enter the boiler through the pipe *D*.

If from any cause the jet should be broken—say from a failure in the water-supply—the steam issuing from the forcing nozzle *K* into the combining-tube *g* will escape through the overflows *m* and *n* and intermediate openings with such freedom that the steam which returns through the annular space formed between the nozzle *K* and combining-tube *g* and escapes into the overflow-chamber through the opening *f*, will not have sufficient volume or force to interfere with the free discharge of the steam issuing from the annular lifting steam-nozzle and escaping

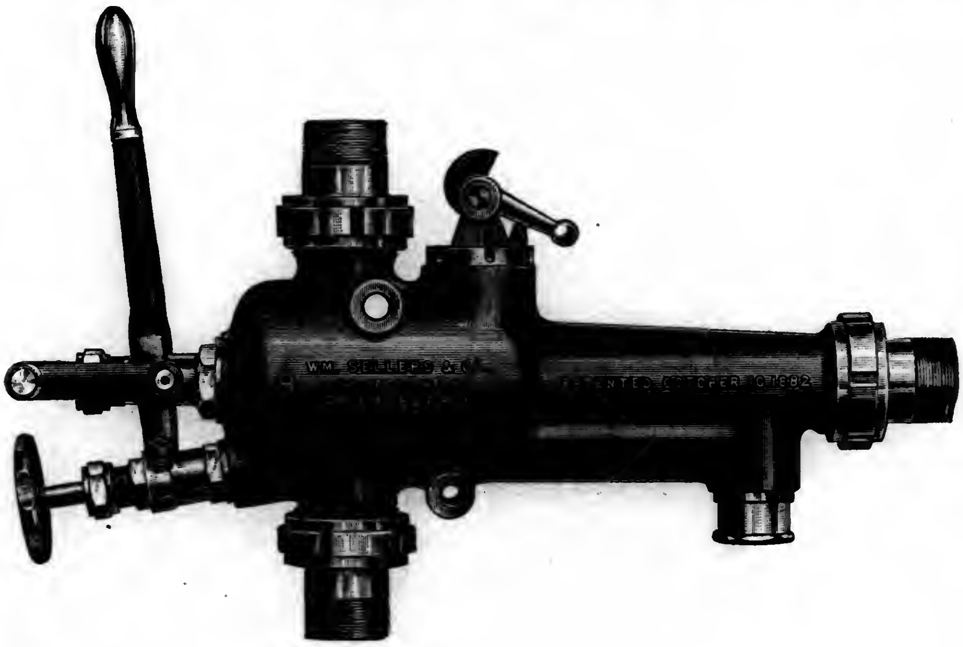


Fig. 141.

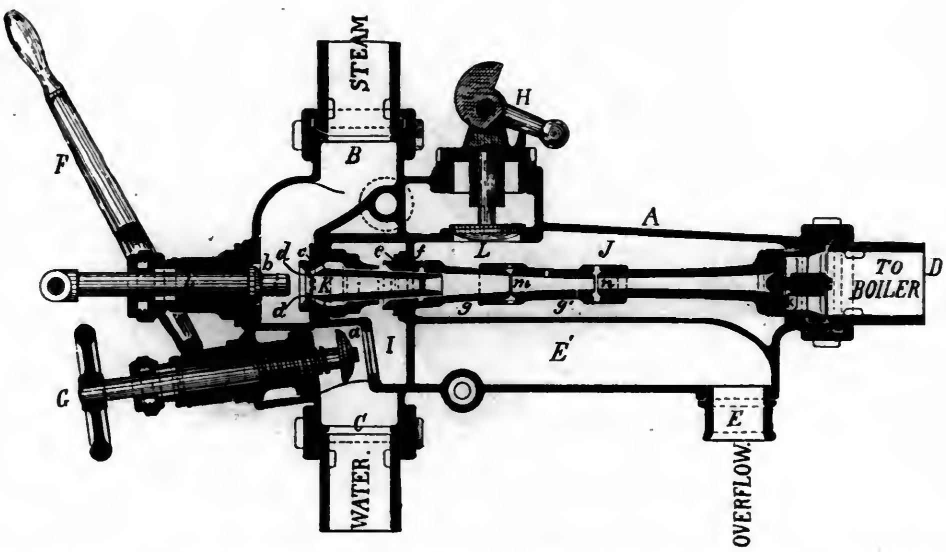


Fig. 142.

opened to allow the water to enter the chamber *I*. Steam is admitted to the chamber *B*, and the lever *F* is operated to lift the valve *b* slightly from its seat. This permits steam to enter the annular lifting steam nozzle *c* through the holes *d d*, while the plug *i* attached to the valve still fills and keeps the tube *K* closed. The steam issuing from the nozzle *c* passes through the annular combining-tube *e* and escapes from the instrument partly through the overflow opening *f* and partly through the overflow openings provided in the combining-tube *g g'*, through the overflow-chamber *J* and passage *E' E*, and produces a strong vacuum in the water-chamber *I*, which lifts the water from the source of supply, and the united jet of steam and water is, by reason of its velocity, discharged into the combining-tube *g*. The spindle *h* is now withdrawn by the lever *F* through the same overflow *f*, and hence the lifting jet will always tend to produce a vacuum in the water-chamber *I*, which will again lift the water when the supply is renewed, and the combined annular jet of steam and water will be forced into the combining-tube *g* against the feeble current of steam returning, when the jet will again be formed and will enter the boiler as before.

If the overflow valve *L* is closed by the lever *H* and steam is then admitted by opening the valve *b*, there will be no outlet for it excepting into the chambers *J* and *I* and if the valve *a* is open into the pipe *C* and thence back to the water-tank. Therefore if it is necessary to turn steam into the supply-pipe or tank to prevent them from freezing, it can be done by closing the valve *L* and opening *a* and *b*.

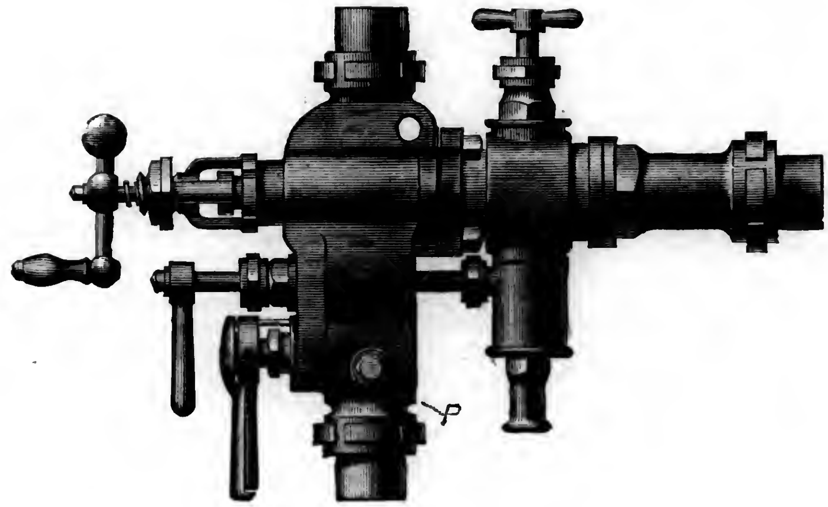


Fig. 143.

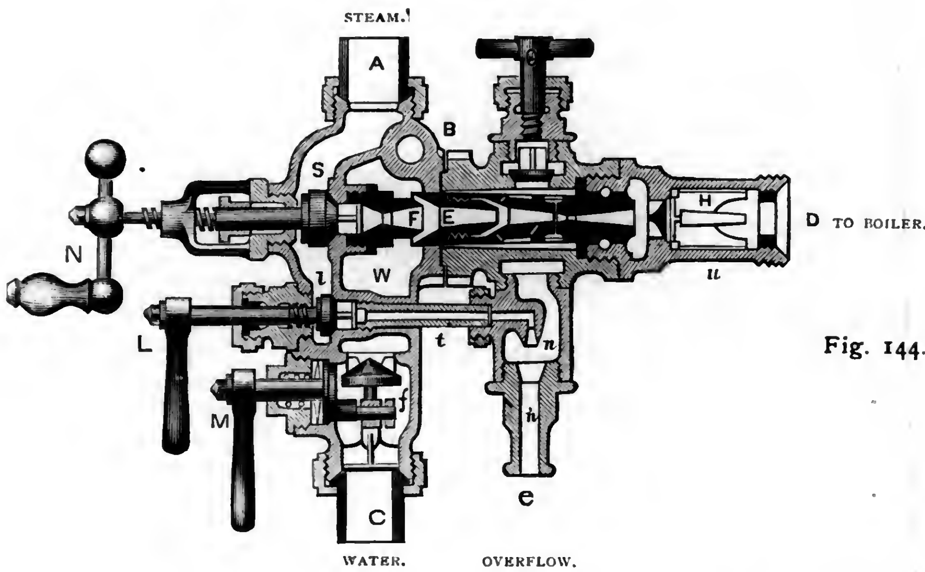


Fig. 144.

MONITOR INJECTOR.

Figs 143 and 144 represent the "Monitor" injector made by the Nathan Manufacturing Company, of New York. It consists of a body, *B*, made in two parts and provided with the usual inlets for steam and water at *A* and *C*, and with a delivery end, *D*. It is further provided with a lifting steam-valve, *l*, which is worked by a handle, *L*; a forcing steam-valve, *S*, worked by the handle *N*, and a water-valve, *f*, worked by a handle, *M*. The handle *O* serves for closing the waste-valve when it is desired to use the injector as a heater.

The operation of the injector is as follows: The water-valve *f* being open and the steam inlet *A* in communication with the boiler, the valve *l* is opened. This operation will admit steam into the tube *t*, which flows through the nozzles *n n'* into the atmosphere, and creates a partial vacuum in the water-chamber

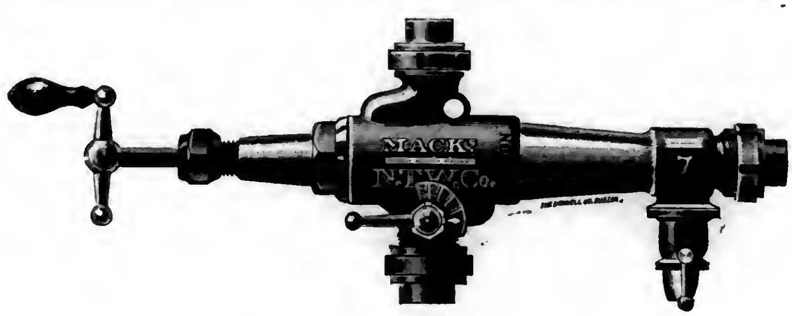


Fig. 145.

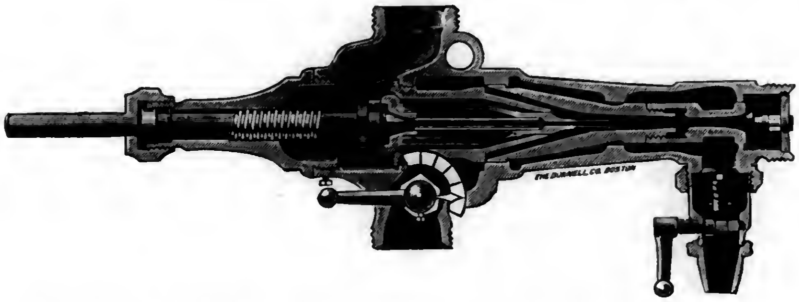


Fig. 146.

W. Water is thus drawn from the supply-tank and is discharged into the combining-nozzle *E*, and through openings in this combining-tube into and out through the overflow at *e*. As soon as the water appears at *e* the valve *S* is opened and the valve *l* is closed. The steam issuing from the nozzle *F* meets the water in the nozzle *E*, and imparts to it sufficient force and velocity to open the check-valve *H* and discharge the fluid at *D* into the pipes leading to the boiler. The supply is regulated by the water-valve *f*.

The lifting apparatus in this injector, it will be seen, is separate from and independent of the forcing nozzles, and has a free discharge into the atmosphere. The forcing nozzles are all fixed nozzles, plain in construction, with large and unobstructed water ways. The parts can easily be removed, and as the lifting as well as the forcing nozzles are in straight lines, small obstructions can be removed by passing a wire through them.

MACK'S INJECTOR.

Figs. 145 and 146 represent Mack's injector, manufactured by the National Tube Works Company, of Boston. From the preceding descriptions its construction and operation will be

Fig. 147.

readily understood. The parts can be easily removed and cleaned, or renewed if worn by the action of impure water.

HANCOCK INSPIRATOR.

Figs. 147 and 148 represent outside and sectional views of the Hancock inspirator, manufactured by the Hancock Inspirator Company, of Boston. In this the lifting and forcing jets and nozzles are independent of each other. *A* is the steam-supply pipe, *B* is the water-supply pipe, *C* is the feed-pipe leading to the boiler, and *O* is the overflow. *D* is the lifting jet, *E* the lifting nozzle, *G* the forcing jet, and *H* the forcing nozzle. *F* is a slide-valve which governs the admission of steam to the nozzles. *I* is an overflow valve for the lifting side of the injector, and *J* a similar valve for the forcing side. In fig. 147 a lever and handle is shown by which the working of the instrument is controlled. This lever is represented in two different positions by the dotted center lines *a b c* and *a' b c'*. It is connected to a fixed pivot or fulcrum, *b*, and at its lower end to a short lever, pivoted at *d*, whose center line is represented by the lines *a d* and *a' d*. This lever has a short arm, *e f*, on its lower end connected to the overflow valves *I* and *J*. Above the fulcrum *b* the lever *a b c* is connected to another lever, *g h i*, *g' h i'*, pivoted at *h*.

When steam and water are shut off the long lever and handle stand in the position shown in fig. 147, and indicated by the dotted line *a b c* in fig. 148. The valve *F* then covers both the

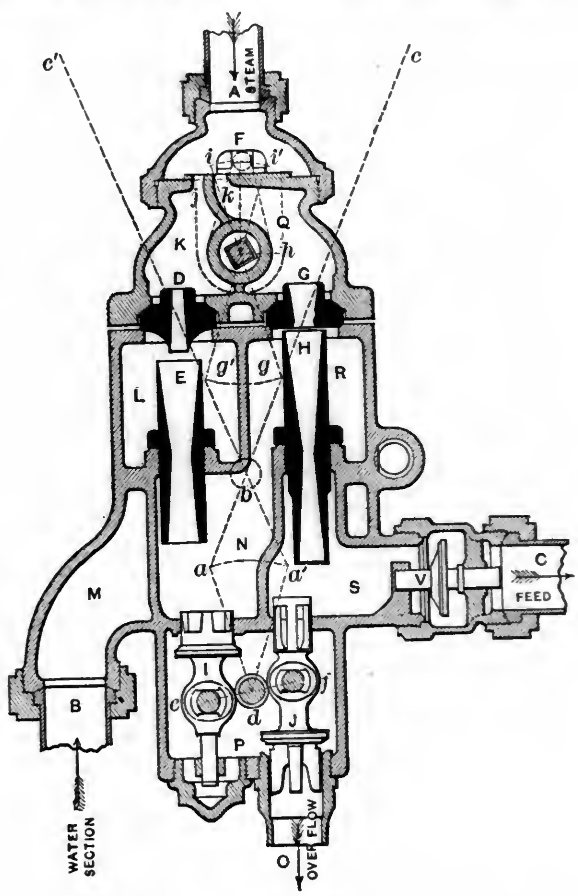


Fig. 148.

steam ports *j* and *k*, and the two overflow valves *I* and *J* are both open. When the upper end *c* of the lever *a b c* is moved toward the left the action of the lever *g h i* moves the valve *F* toward the right, which uncovers the steam-port *j* and admits steam into the chamber *K*; this steam flows through the jet *D* and the nozzle *E*, which produces a partial vacuum in *L*, which communicates with *M*, and water is thus drawn up through the pipe *B*, and is carried along by the jet and escapes through the overflow valve *I* into the chamber *P*, and thence through the valve *O*. After a current is thus established the lever *a b c* is moved still farther toward the left-hand side, which closes the valve *I*, and the water then fills the chamber *N* and rises until it reaches the top of the nozzle *H*. The lever *a b c* is moved still farther toward the left, which moves the valve *F* so as to admit steam to the port *k* and chamber *Q*. This steam flows through the jet *G* and nozzle *H* and carries the water in the chamber *R* with it into the chamber *S*, from which it escapes through overflow valve *J* and pipe *O*. After the current is established the lever *a b c* is moved still farther to the left, which closes the valve *J*, and the water is then forced from the chamber *S* through the check-valve *V* and pipe *C* into the boiler.

The action of the instrument is thus controlled by the movement of the one lever. A valve for regulating the supply of water is attached to the pipe *B*, but is not shown in the engraving.

QUESTION 253. *What attachments are needed in connection with an injector to make it effective?*

Answer. A valve should be placed in the pipe by which the injector is supplied with steam. This valve is to be closed only when there is occasion to remove the injector when steam is up, and in cold weather, to prevent the condensation of steam in the pipes at the end of its trips. During the time that the injector is working this valve should be wide open.

QUESTION 254. *In what position are injectors usually placed?*

Answer. They are put inside the cab in a position where they can be easily inspected by the locomotive runner.

QUESTION 255. *What is required to keep an injector in good working order?*

Answer. Constant use is better than occasional use. When

there are two injectors in an engine, one on each side, the one on the runner's side should be used while running, and the other one when the engine is standing still. All pipe connections must be tight, so as to prevent the leaking of air. The pipe carrying steam to the instrument should be from such part of the boiler as will insure the use of dry steam, and the waste-pipe must not be contracted.

QUESTION 256. *How can the height of the water in the boiler be known?*

Answer. Two appliances are used by which the height of the

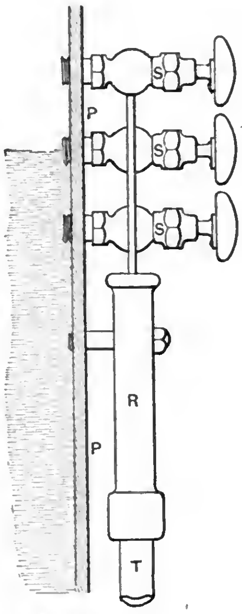


Fig. 149.

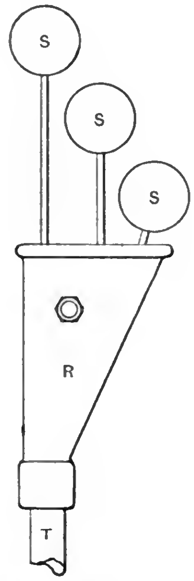


Fig. 150.

water in the boiler can be observed. These are: 1. *Gauge* or *try cocks.* 2. The *glass water gauge.*

Every locomotive is provided with three or more gauge-cocks, which are usually placed at the back end of the boiler, where they can easily be seen and reached. These cocks, *S, S, S, S,* are shown in figs. 149 and 150, which represent the end plate, *P P,* of the boiler in section. They communicate with the inside of the boiler and are so placed that one is three or four inches above the other. The upper cock is placed above the point where the surface of the water should be when the engine is working, and the lower one below it, so that the upper one communicates with the steam-space and the lower one with the water. When these cocks are opened, if the water is at its proper height, steam is discharged from the upper one, and water from the lower one.

When a gauge-cock which communicates with the steam-space is first opened, it is usually filled with condensed water, so that it should generally be kept open for a little while until this water is discharged. If the upper cock is opened and continues to discharge *water,* it indicates that there is *too much* water in the boiler; on the other hand, if steam is discharged when the lower cock is opened, then there is too little water in the boiler, and the heating surface is in danger of being exposed to the fire without being covered with water, and consequently overheated, or, as it is called, "burned," and so injured as to become too weak to bear the strain to which it is subjected by the pressure of the steam. There is then great danger that the crown-sheet may be crushed down by the pressure of the steam above it, or that the boiler may be exploded. Even if no accident occur, the boiler is in great danger of permanent injury from overheating when the water is allowed to get too low.

Below the gauge-cocks, fig. 150, a receptacle, *R,* called *a drip,* is placed to receive the water and steam which are discharged from the cocks. This water is conducted away by the pipe *T.*

The *water-gauge P,* fig. 151, consists of an upright* glass tube, *a a,* which is from $\frac{1}{2}$ to $\frac{3}{4}$ in. in diameter, and from 12 to 15 in. long. The glass is about $\frac{1}{8}$ in. thick. At its ends it communicates with the steam and water of the boiler through brass elbows, *b, c.* The openings in these elbows, which communicate with the boiler, are closed by the valves or plugs, *d, e,* which are worked by screws and handles, *f, g.* The glass tube, when it is attached to the elbows, is made steam-tight by rubber rings, which are pressed tight around the tube by *packing-nuts, h, i.* The elbows are provided with the valves *d, e,* so that in case the glass tube breaks the steam and water can be shut off, so as not to escape through the elbows. The lower elbow is provided with a blow-off cock, *k,* through which any sediment or dirt which collects in the glass tube or elbows can be blown out. When the valves in the upper and lower elbows are opened the steam flows into the glass tube through the upper one, and water through the lower one, and the water assumes a position in the glass tube on a level with the surface of that in

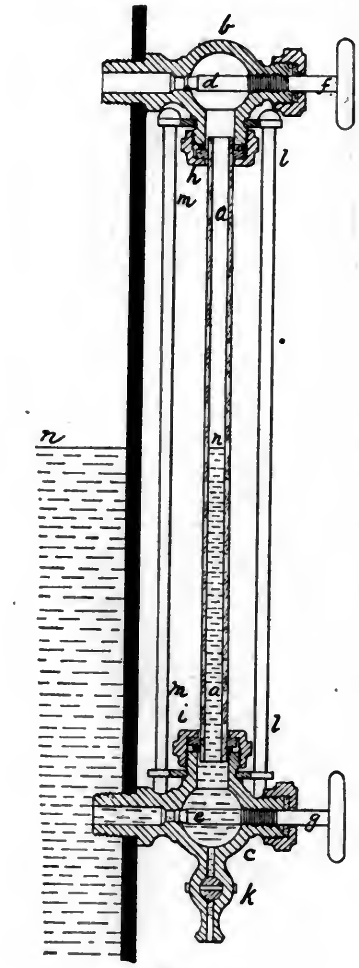


Fig. 151.

the inside of the boiler—that is, the position of the water in the boiler becomes visible in the glass tube. On account of the constant variations of the water in the boiler, the column of water in the glass never remains stationary, but plays up and down as long as the boiler is working. But if the communication between the glass tube and the boiler is closed, then the water in the tube becomes stationary and the water-gauge is useless. In order that there may be no obstruction of the glass tube by mud or dirt from the water, it must be *blown out* often. To do this the lower valve, *e,* is closed, and the blow-off cock *k* and the steam-valve *d* are opened. The steam pressure in the tube on top of the column of water will force it out of the blow-off cock, and the mud and dirt will be carried with it.

If from any cause the glass tube is broken, first of all the water-valve *e* should be closed and then the steam-valve *d,* so

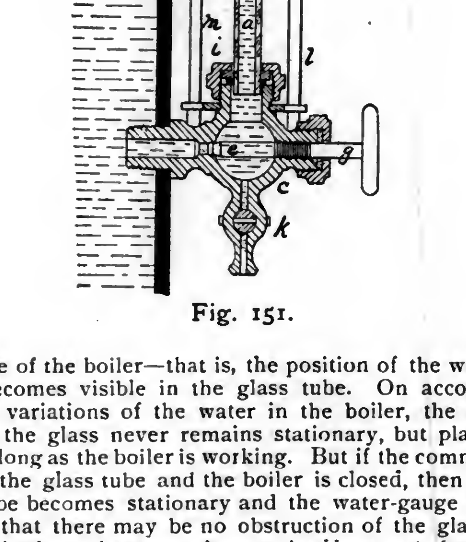


Fig. 152.

as to prevent the hot water and steam which will escape from the broken glass from scalding those who are working the engine. By unscrewing the nuts *h* and *i* the old glass can easily be removed and a new one substituted in its place. Care should be taken in putting in new glasses not to screw the pack-

* Sometimes these tubes are, for convenience, inclined.

ing-nuts down any more than just sufficiently to make the rubber rings steam-tight around the glass tubes. If they are screwed too tight they are apt to produce a strain on the tube, so that the slightest expansion by heat or contraction from cold will break it.

QUESTION 257. *What safeguard is used in locomotives to guard against the danger of low water?*

Answer. What are called *safety-plugs* are inserted in the highest part of the crown-sheet. These consist of hollow brass plugs, fig. 152, with a cavity, *C*, in the center, which is filled with metal that melts at a low temperature. The plug is screwed into the crown-sheet *A'A*, and its lower end is exposed to the fire. In case the water gets low and the plate is dangerously overheated, the fusible metal melts and runs out of the plug, so

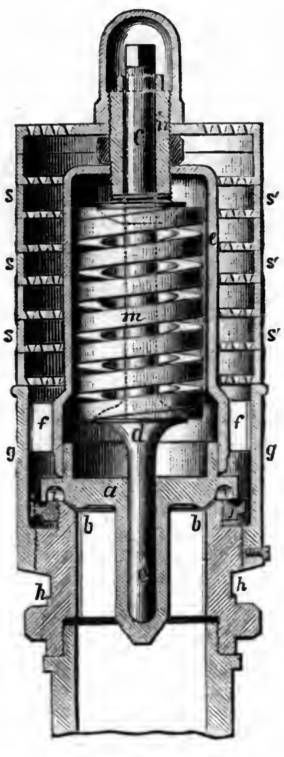


Fig. 153.

that steam can escape through it, which thus gives warning of the danger, and relieves the pressure in the boiler.

QUESTION 258. *How is the steam pressure in boilers prevented from exceeding a certain limit?*

Answer. By what are called *safety-valves*. These consist of circular openings, *b b*, fig. 153, about 3 in. in diameter, placed usually on the top of the dome, and covered by a valve, *a*, which is pressed down by a spring, *m*. Two of these valves are usually placed on the top of the dome, so that if one gets out of order the other one will allow the steam to escape as soon as its pressure exceeds that which it has been decided the boiler can safely bear. This pressure in locomotive boilers is usually from 120 to 170 lbs. per square inch.

QUESTION 259. *How is the amount of pressure which must bear on top of a safety-valve determined?*

Answer. This pressure is determined BY MULTIPLYING THE AREA OF THE OPENING FOR THE VALVE IN SQUARE INCHES BY THE GREATEST STEAM PRESSURE, IN POUNDS PER SQUARE INCH, WHICH THE BOILER IS INTENDED TO BEAR. Thus, if the opening for a safety-valve is 3 in. in diameter, its area will be 7 square inches, and, therefore, if the greatest steam pressure which it is intended that the boiler shall bear is 150 lbs. per square inch, the valve must be pressed down with a pressure equivalent to $7 \times 150 = 1{,}050$ lbs.

QUESTION 260 *How are safety-valves constructed?*

Answer. They are made in a variety of forms. Fig. 153 represents a section of Richardson's safety-valve, which is now in general use. *a* is the valve which rests on the seat *b b*, *c c'* is a spindle, the lower end of which rests on the bottom of the hole in the center of the valve *a*. A spiral spring, *m*, rests on a shoulder, *d*, on the spindle. The pressure on the spring is regulated by the nut *n*, which screws into the case *e*. This case is connected by ribs *f f* to the outer case *g g*, into which the seat *b b* is screwed at *h h*. The valve has a groove, *i i*, around its outside rim. As the valve raises it compresses the spring, which increases its resistance, and therefore without some provision to obviate this difficulty it would be raised only a very short distance above the seat after steam commenced to blow off. For this reason the top, *a*, of the valve is made considerably larger in diameter than the opening at *b b*; in the under side of the valve a groove, *i i*, is turned. When the valve lifts, this groove is filled with steam, which presses against that portion of the valve outside of the opening *b b*, which causes the valve to raise higher and remain open longer than it would without this device. A ring, *j*, is screwed to the outside of the seat *b b*. This can be screwed up or down, and in this way the amount of opening around the edge of the valve can be regulated.

The safety-valves are usually fitted into conical seats, *b b*, so as to be perfectly steam-tight, and are made with wings or guides. These guides are intended to keep the valves in the proper positions in relation to their seats.

QUESTION 261. *What precaution must be taken to prevent reckless or ignorant persons from increasing the pressure in the boiler beyond that which it is thought it will safely bear?*

Answer. This is usually done by arranging one of the safety-valves with a lever and the other without. The latter is often covered and sealed or locked up, so as to be beyond the control of the locomotive runner.

QUESTION 262. *How can it be known that the safety-valves are in good working order?*

Answer. The one which has a lever should be frequently

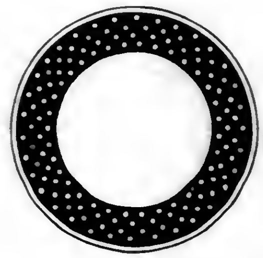


Fig. 154.

opened, as there is always danger that a safety-valve, or some of its attachments, may become corroded or otherwise disordered, so that it will not act promptly or with certainty.

QUESTION 263. *How is the noise of the steam which escapes from a safety-valve diminished?*

Answer. By what are called *mufflers*. These are constructed in a variety of ways. The principle on which they all act is to subdivide the current of steam, which reduces its noise. Sometimes a vessel is filled with pebbles or glass beads, and the escaping steam is made to pass among them. Fig. 151 shows the arrangement used with Richardson's valve. This consists of a series of perforated plates or discs, *s s'*, *s s'*, which are

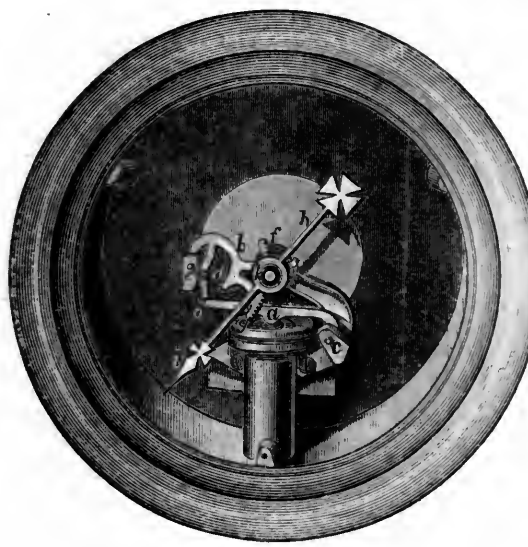


Fig. 155.

shown in a plan view in fig. 152. These are placed one on top of the other, and have a space between them. The steam is thus alternately contracted in passing through the holes and expanded in the spaces above them, and in this way escapes through the top plate with very little noise.

QUESTION 264. *How is the steam pressure in the boiler indicated?*

Answer. By an instrument called a *steam-gauge.* There are a great variety of such instruments made, but they may all be divided into two classes, and they all operate upon one of two principles. In the one class the pressure of the steam acts upon diaphragms or plates of some kind, as shown in fig. 156, which represents a section of a pair of plates of this kind. *A A* are metal plates made with circular corrugations, as shown in section and also by the shading. The steam enters by the pipe *c* and fills the chamber between the metal plates or diaphragms. The corrugations of the latter give them sufficient elasticity, so

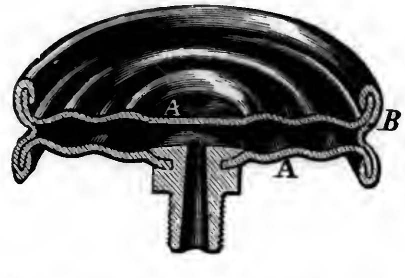


Fig. 156.

that when the pressure is exerted between them they will be pressed apart by the steam. If they were flat, it is plain that they would not yield, or only to a very slight degree, to the pressure of the steam.

Fig. 155 represents a view of a steam-gauge of this kind with its face removed. The diaphragms are shown just below *a*. A bent lever whose fulcrum is at *c* bears on the diaphragm at *a*, and is connected by a short rod, *o d*, to a bent lever, *b*, whose fulcrum is at *e*. This lever has a toothed segment, *f g*, which gears into a pinion on a spindle, *k*. This spindle carries an

Fig. 157.

index hand or pointer, *h i*. It is plain that any upward movement of the diaphragm below *a* will lift the lever *o a c*, and its motion will be communicated to the lever *b*, and by the segment and pinion to the pointer, and it will indicate the steam pressure on a dial similar to that shown in fig. 157.

QUESTION 265. *What other kind of steam-gauge is used?*

Answer. In the other class of gauges, shown in figs. 157 and 158, the steam acts upon a bent metal tube, *a b c*, of a flattened or elliptical section. It may not be known to all readers that if a tube having a section of that form is bent, say in the shape of the letter **U** or **C**, and is subjected to the pressure of a liquid or gas on the inside, the force exerted by the pressure will tend to straighten out the tube. This is due to the effect of pressure on the inside of an elliptical or flat section, which changes its shape and causes it to approximate to a circular form. Thus let *A B*, fig. 159, represent a cross section, and *a b d c* a longitudinal section of a part of such a tube contained between two radii, *o a* and *o b*, drawn from the center *o* of the curve in which the tube is bent. If now we subject the inside of *A B* to a pressure it will have a tendency to assume the form of the circle *C D*, and would then be represented in the longitudinal section by the dotted line *a' b' d' c'*. If we draw radial lines through *a' c'* and *b' d'*, it will be found that they intersect at *o'* instead of *o*, which was the original center of the curve of the tube. It will be seen that as the section of the tube approximates to the form of a circle, the side *a b* which is outside the curve will be moved farther from the center, while the other side, *c d*, is moved nearer to it. As indicated by the radial lines, when this occurs either the outside

Fig. 158.

must be lengthened and the inside shortened, to conform to the radial lines *a o* and *b o*, or else the tube will be straightened so that the radial lines will assume the position *a' o'* and *b' o'*.

In the gauge represented in fig. 158 (in which the dial-plate is removed), one end, *c*, of the tube is attached to a bent lever, *c f l m*, which is connected by a rod, *g*, to a toothed segment, *e*. The end *a* of the tube is connected with the lever at *f*. It is obvious that as the two ends of the bent tube are forced apart

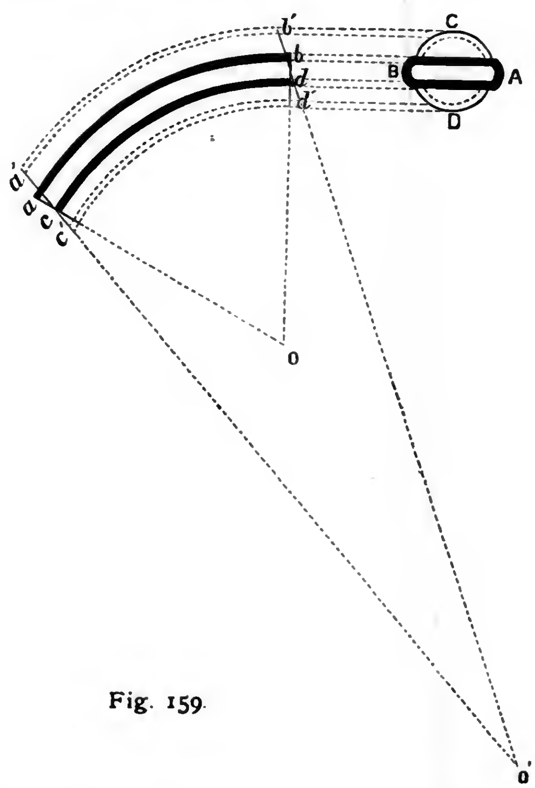


Fig. 159.

by the steam pressure, the lower end of the lever and the segment will be moved toward the left hand side. The segment gears into a pinion on the spindle *s*, which carries the index or pointer, *p p*, which indicates on the dial, fig. 157, the degree of pressure in the tube. The latter is connected with the boiler by a tube attached at *h*. The gauge shown by figs. 157 and 158 is made by the Ashcroft Manufacturing Company, of New York. Various forms of this kind of steam-gauge are made, but all act on essentially the same principle.

The pipe which connects the steam-gauge with the boiler is usually bent to prevent the hot steam from coming in contact with the metal plate or tube, as it is found that the heat of the steam affects their elasticity. When a bent tube is used, the steam from the boiler is condensed and fills the bent portion so that when the steam pressure comes on the surface of the water it forces it up the other leg of the tube into the gauge. A cock is attached to this pipe so that the steam can be shut off in case the gauge should get out of order or require to be removed while there is steam in the boiler.

QUESTION 266. *How can the accuracy of a steam-gauge be tested?*

Answer. When the gauge is in good working order, the index or pointer moves easily with every change of pressure in the boiler, and if the steam is shut off from the gauge, the index should always go back to 0. In order to determine the accuracy of its indications, however, they should be tested with a column of mercury. This consists of a long, vertical tube, terminating at its base in a closed vessel filled with mercury. The gauge is then attached to the top of this vessel and water or oil is forced into the vessel on top of the mercury and into the gauge. A pressure of one pound per square inch will force up the column of the mercury 2.04 in., so that by graduating the tube into spaces that distance apart, the divisions will indicate the pressure in pounds per square inch. Thus, a pressure of 50 lbs. would force up the column of mercury 102 in., and with 100 lbs. pressure the column would rise 204 in., and therefore, when

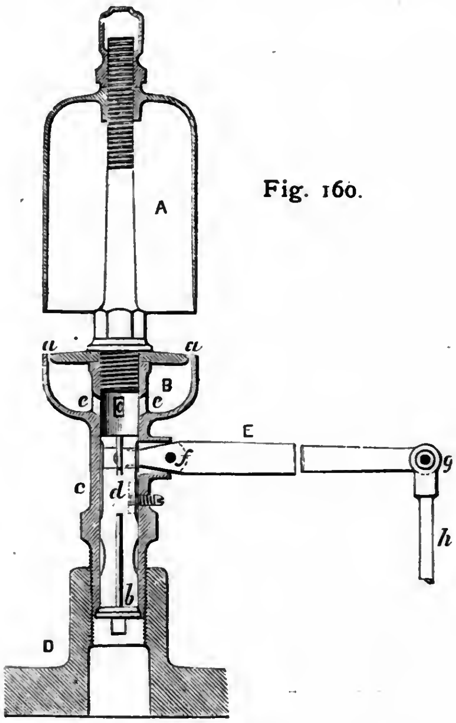


Fig. 160.

the mercury reaches these or any other points, the steam-gauge, if it is accurate, should indicate equivalent pressures.

The ordinary steam-gauges are very liable to get out of order, and therefore they should be frequently tested to ascertain whether their indications are correct.

QUESTION 267. *What is the steam-whistle, and for what purpose is it used?*

Answer. The *steam-whistle* shown in section in fig. 158 consists of an inverted metal cup or bell, *A*, made usually of brass. The lower edge of this cup is placed immediately over an annular opening, *a a*, from which the steam escapes and strikes the edge of the cup or bell, which produces a deep or shrill sound, according to the size or proportions of the whistle. The annular opening *a a* is formed by the plate or cover *a a*, which nearly fills the mouth of the cup *B*, which is attached to the stem *c*. The latter is screwed into the top, *D*, of the dome. Communication with the steam-space of the boiler is either opened or closed by a valve, *b*, which is attached to a sort of spindle, *d*, which extends upward inside of the stem *c*. This spindle does not entirely fill the opening in the stem *c*, so that the steam which enters when the valve *b* is opened rises and escapes through the holes *e, e, e*, into the cup *B* and out through the annular opening *a a*. The valve is opened by the lever *E*, whose fulcrum is at *f*. The end, *g* of this lever is connected by a rod, *h*, with the cab, and by a suitable handle or lever the valve can be opened and the whistle be blown at any time by the locomotive runner or fireman to give signals to the trainmen, or of the approach of a train to the station, or to warn persons to get off of the track.

QUESTION 268. *How is a locomotive boiler emptied and cleaned?*

Answer. One or two large cocks, called *blow-off* cocks, are placed near the bottom of the fire-box, either in front or behind, and sometimes on the side. By opening either of these the water in the boiler is blown out, and much of the loose mud and dirt is carried out with the water.

In order to clean out the mud and scale which are not entirely loose, what are called *mud-plugs* or *hand-holes* are placed in the corners of the fire-box near the bottom. The former are screw-plugs, which can easily be unscrewed. The latter are oval-shaped holes, about 4½ in. long and 2½ in. wide, and covered with two metal plates, one of which is put inside the boiler and the other outside, and fastened with a bolt through both. Another hand-hole is sometimes placed in the bottom of the front tube-sheet. When the boiler is emptied of water the hand-holes are opened by unscrewing the plugs or taking off the covers, and as much dirt is removed as can be scraped out of these holes. A hose-pipe is then inserted and a strong stream of water is forced in, which washes out nearly all the loose dirt, so as to leave the boiler comparatively clean.

When the water is very impure, what is called a *mud-drum* is sometimes used. This is a cylinder of wrought iron attached to the under side of the boiler usually near the smoke-box. It has a cast-iron cover on the bottom which can be removed to clean it. It also has a blow-off cock to discharge the water in it. Much of the mud and dirt is deposited in this receptacle, from which it can easily be removed by taking off the cast-iron cover or blown out through the blow-off cock.

QUESTION 269. *What other attachments are there to the boiler of a locomotive?*

Answer. There is a cock, called a *blower-cock*, which is connected to the chimney by a pipe. Steam is conducted through this pipe, and escapes up the chimney in a jet, thus producing a draft when the engine is not working. This arrangement is called a *blower*, and is used to blow the fire when the engine is standing still. The action of the jet is similar to that of the exhaust steam which escapes up the chimney, excepting that the steam from the jet escapes in a continuous stream instead of distinct "puffs," as it does when it is liberated alternately from one end of the cylinders and then from the other.

E, fig. 90, is the furnace door, which is fastened by a latch. The latter has a chain attached to it, by which it can be conveniently opened or closed.

QUESTION 270. *How are the grates constructed?*

Answer. As has already been explained, they are made usually of cast-iron bars,* *A, A, A*, figs. 161 and 162, called *grate-bars*. Fig. 161 is a plan, and fig. 162 a horizontal section of one form of grate. The bars in this kind of grate are usually cast in pairs, or sometimes three or more are cast together. They are made wider on the top than on the bottom edges, as shown in the section, fig. 163, so that cinders and ashes will fall through easily, and also to give free access to the air from below. They are usually from ¾ to 1½ in. wide on the top, and about ⅜ in. on the lower edges. The spaces between the bars are made from ½ to 1½ in. wide. For burning wood the bars are placed comparatively close together and are stationary, but for burning bituminous coal they are usually made so that they can be moved, in order to shake or stir up the fire, just as is necessary in an ordinary stove or grate fire. In the grate we have illustrated the bars *A, A* are cast in pairs, and run crosswise of the fire-box. The ends are made with a sort of journal, *b, b*, which rest on two supports, *B, B*, called *bearing-bars*, which have suitable indentations to receive the ends of the grate-bars. The latter have arms, *C, C*, fig. 162, cast on the under side, to which a bar, *D D*, is attached. By moving this bar back and forth, the grate-bars have a rocking motion imparted to them, as shown in fig. 163. It is evident that in this way the fire over the whole surface of the grates will be disturbed or shaken. The bar *D D* is moved by a suitable lever in the cab. Grates which have movable bars are called *shaking* or *rocking grates*. A great variety of such grates are made and in use, to describe which would require more room than is available here.

For burning anthracite coal what are called *water-grates* are used. These consist of wrought-iron tubes, 2 in. in diameter outside, which are fastened in the front and back plates of the fire-box and are inclined upward from the front end, so that there will be a continued circulation of water through them to keep them cool and thus prevent them from being burned out by the intense heat of the fire.

* In Europe generally, and in some few cases in this country, the grate-bars are made of wrought-iron.

Fig. 161.

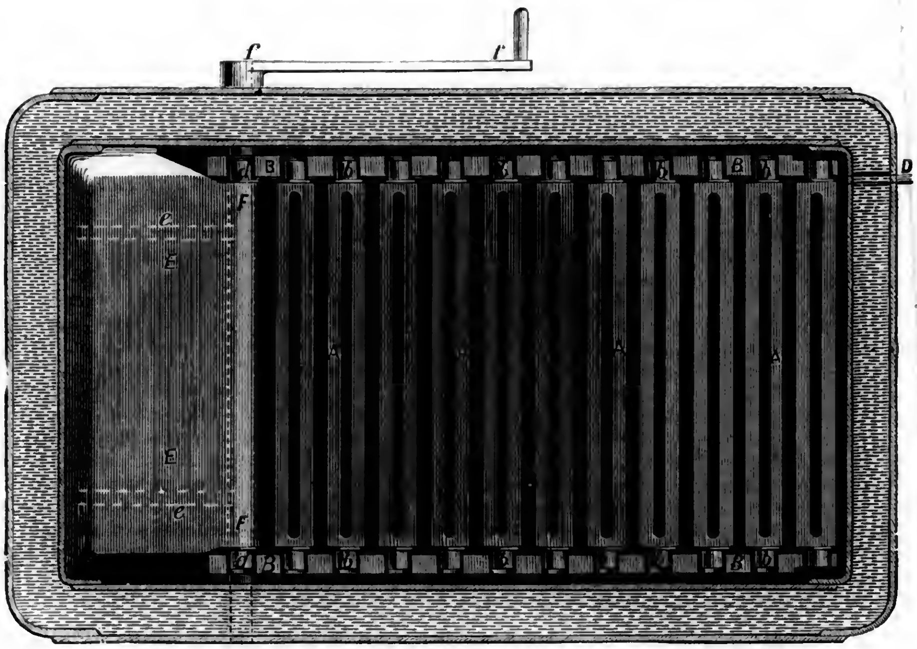
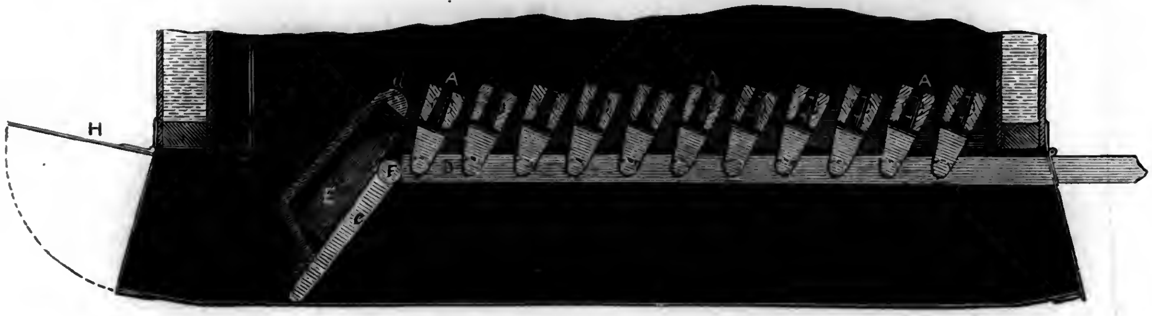


Fig. 162.

Fig. 163.



The tubes usually have about four solid wrought-iron bars between that number of tubes. These bars can be withdrawn, and the fire then falls into the ash-pan through the opening left by the withdrawal of the tubes.

QUESTION 271. *How is the fire removed from the fire-box when it is necessary to do so?*

Answer. In bituminous coal-burning engines, what is called a *drop door*, *E E*, figs. 161, 162, and 163, is provided for that purpose. This door is supported partly on journals, *d*, *d*, similar to those in the grate-bars, on which it can turn, and is held up or prevented from dropping by arms, *e*, *e*, attached to a shaft, *F F*. This shaft is operated by a lever, *f f*, fig. 161, outside the fire-box.

When the arms are in the position represented in fig. 162, the drop-door is held up in the place in which it is shown; but when they are turned as in fig. 163, the door falls down so that the burning coal can be taken out of the opening at *G*, and, by raising up the ash-pan damper, *H*, fig. 163, can be raked out on the track or into suitable pits usually provided for this purpose. The drop-doors are sometimes perforated so as to admit air to the fuel on top of them.

QUESTION 272. *How is the damper of the ash-pan operated?*

Answer. It is connected by a rod to a bell-crank, which is moved by the handle, which is raised or lowered, thus opening or closing the damper.

(TO BE CONTINUED.)

Manufactures.

Diamonds and Emery Wheels.

AT a meeting of the New York Academy of Sciences, held in April, 1885, Mr. George F. Kunz, the gem expert, exhibited and described a remarkable diamond, which was made up of a multiplicity of twinnings, and was of the character called "extreme durante" by the French. Experiments were soon after conducted by Messrs. Tiffany & Co., who were owners of the diamond, to produce polish sufficient to give the brilliancy necessary in any diamond gem. Its table had been placed on a diamond polishing wheel for 100 days, and the average circumference of that part of the wheel on which it was placed being $2\frac{1}{2}$ ft., the surface that travelled over the diamond table amounted to over 75,000 miles. The diamond fairly plowed the wheel, practically ruining it, so that it required planing before it could be further used.

The stone was kept by Messrs. Tiffany & Co. as a curiosity until November, 1887, when it was bought by the Tanite Company, of Stroudsburg, Pa. The diamond was put to work in the turning room of their establishment, the first solid emery wheel it turned being a coarse, hard wheel 36 in. in diameter and 8 in. thick. In the turning of this wheel the diamond lost

$\frac{1}{32}$ carat in weight. It is a striking fact that a gem of such extreme hardness as is indicated by Messrs. Tiffany & Co.'s experiments should wear so rapidly under the action of a Tanite wheel. As the wheels made by this company are all trued up in a lathe by diamond-pointed tools, the cost of diamonds is quite an item in the expenses.

A New Oil Burner.

A NEW burner of the spray or jet type for burning oil in boiler furnaces has recently been introduced, which has so far shown very good results. In this burner the scattering or atomizing is effected by passing the oil under pressure through a tube containing a revolving screw. The oil issues in the form of a cone made up of extremely small drops, and meets a current of air, also forced in by a screw. This burner is shown in the accompanying illustrations.

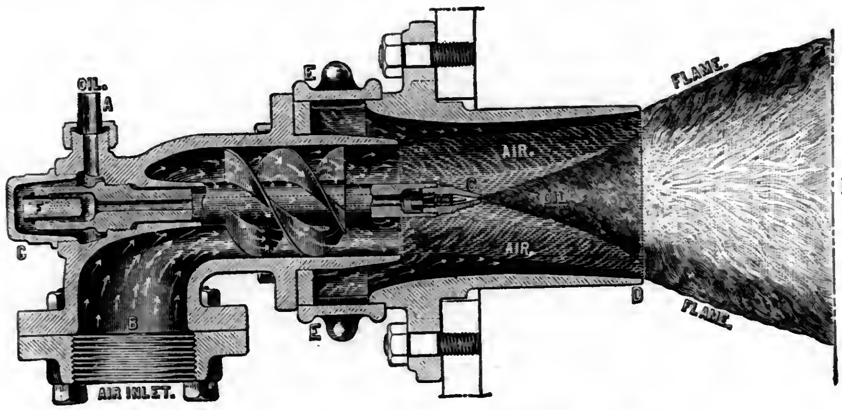


Fig. 1.

Fig. 1 is a section of the burner, in which *A* is the attachment for the oil ; *B* the air inlet ; *C* the discharge nozzle for the oil ; *D* the discharge end of the burner, and *E* a slide controlling an auxiliary inlet through which additional air is drawn by the action of the central discharge. *F* is a strainer fitted in the oil-tube to prevent dirt from passing through. By taking off the cap *G* this strainer can be cleaned out. In the same way the whole tube can readily be removed and the spray-nozzle *C* examined, by unscrewing and taking apart.

The oil must be supplied to the burner under a pressure of not less than 35 lbs. This pressure can be obtained by a closed tank and steam pressure, or in several other methods ; usually a small steam pump will be the most convenient.

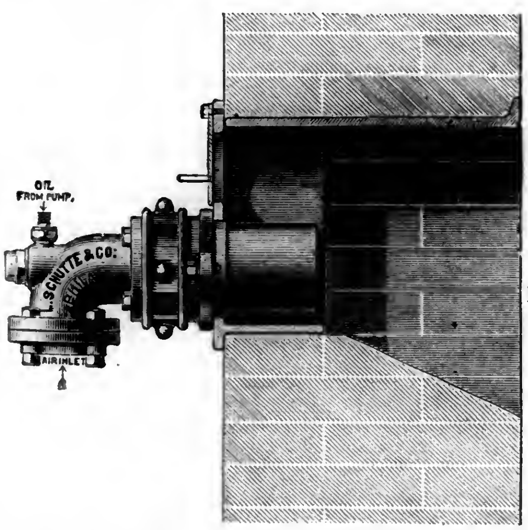


Fig. 2.

The makers give the following hints as to the use of this burner :

"For the purpose of starting the burner before steam is at disposal, the steam-pump can be fitted with a hand-power attachment, but a separate small steam-boiler, or an accumulator, containing a sufficient quantity of oil under pressure, will always be a desirable part of a large oil burner plant.

"The regulation of the burner—viz., the quantity of oil discharge, is had through difference in pressure. Thus, while the pump is set to discharge under a permanent pressure of 150 lbs., the oil inlet to each burner can be so throttled that discharge from burner is under 35 lbs. only, thereby reducing the quantity to less than one-half of what it would be if discharging under 150 lbs. The throttling is done by a small valve in oil branch pipe to each burner.

"The burner can be used with or without blast. Generally, it will not be found necessary, and may even not be desirable to have blast, but where it is required, the pressure need be but low, say from 1 to 3 ounces. A steam jet blower or an ordinary fan blower will furnish blast of suitable pressure, while the connecting pipe should be fitted with a gate for the regulation, if there be an excess of pressure.

"The quantity of the blast is not intended as a supply for combustion. It need be but sufficient for ignition, while a somewhat larger volume is not harmful. . . . .

"The numerous devices in furnace construction, as second combustion chambers, providing for hot air admission, and all improvements leading to perfect combustion or to maintain flame through long passages, apply with advantage to the burning of oil, equally as with coal firing.

"The location of the burner depends entirely on the form of the furnace and the convenience with which it can be attached

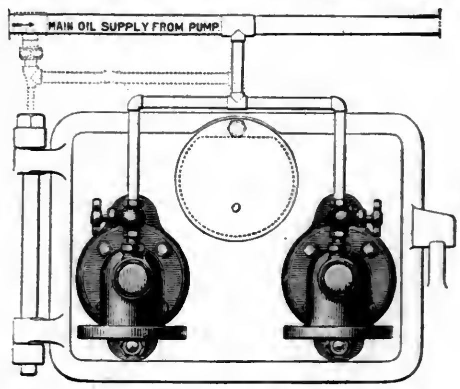


Fig. 3.

and operated. It may be fixed horizontal or at an angle with the direction of the flame, upward or horizontal, through the front, through the back, or through the side walls.

"Where the flame has to extend through flues, as under cylinder boilers, in heating furnaces, and under evaporating pans, a favorable direction of the flame is readily arranged. Where, however, the fire-box is short, as is the case in boilers of the locomotive and marine type, or upright tubular, it may be found desirable to direct the flame against a bank of fire-brick, for better distribution. . . . .

"In connection with the attachment of an oil burner to a furnace, particular attention should be paid to the location and volume of air admission. It is well understood that too large an admission, over and above that required for combustion, will cause a lowering of the temperature and a consequent uneconomical result. . . . .

"There is one feature in the burning of oil, as in the burning of natural gas, of which we desire to make mention, the formation of a bank or cake of carbon at a point generally slightly in front of the flame. The amount of this carbon varies with different oils, as also with the arrangement of the furnace. Strange to say, this carbon does not burn in the oil furnace, while when taken out it is the very best fuel.

"The reason for its formation is given in the fact that if unignited parts of oil strike hot fire-brick or other surface of certain temperature, carbon is deposited, while the remainder forms into a gas, which is burned. In long furnaces the formations will be less than in short ones, and while there is little or none with light oils, there will be more when burning heavier oils."

The remaining illustrations show several methods of attach-

ing this burner to boiler furnaces. Fig. 2 shows the burner fixed through the brick wall of a furnace ; in this case a square-cornered iron frame is used with a plate in front having two holes, one to receive the burner, the other closed by a door, for the purpose of introducing the lighting torch and observing the flame.

In fig. 3 two burners are shown fixed through the fire-door opening on a plate, which is carried by the hinges provided for

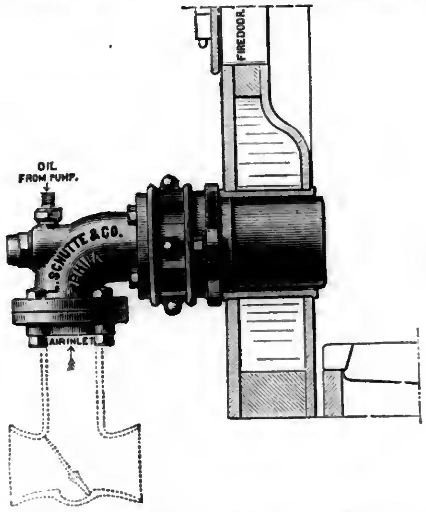


Fig. 4.

the fire-door. In fig. 4 it is shown attached to a locomotive boiler, a tube being inserted through the outer shell and fire-box.

Messrs. L. Schutte & Co., of Twelfth and Thompson Streets, Philadelphia, are the manufacturers of this device, which they have named the "Cyclone" burner.

New Bridge Structures.

A NEW bridge is about to be built at Sugar River on the Rome, Watertown & Ogdensburg Railroad, consisting of one iron lattice span of 85 ft. and one pin span of 150 ft., to replace Whipple trusses, which, although strong enough to carry the traffic when constructed, are now considered too light to resist the strains resulting from the present increased weight of rolling stock passing over the road. One end of these spans is on a considerable skew, but this objectionable feature has been entirely eliminated by an arrangement of trusses and end stringers which secures the same results as if the skew did not exist. The design has been prepared by Professor P. C. Ricketts, Consulting Engineer, of Troy, N. Y , the Bridge Engineer of this road.

THE iron viaduct at Utica over the Delaware, Lackawanna & Western and the New York Central tracks, mentioned some time ago in the JOURNAL, is now about completed. A great deal of difficulty was experienced in getting a solid foundation, it having been found necessary to drive piles in some cases from 20 to 30 ft. During the excavation for the purpose of cutting off these piles at low water level in the Mohawk River an old trestle formerly in use by the Delaware, Lackawanna & Western was uncovered and the fact noted that for a distance of 6 ft. above high water the timbers were entirely sound, although at least 20 years old. This was probably due to the fact that, having been buried in the ground, they have been kept moist. This structure as a whole makes a marked feature on the line of the New York Central, adding one more to the many over and under crossings by which it is characterized.

THE Delaware & Hudson Canal Company has recently put into service an extensive coal terminal at Weehawken, N. J., consisting of 550 ft. of wrought-iron viaduct, comprising a single-track incline 300 ft. in length with a grade of 17 per cent., branching at its summit into a viaduct with four tracks above and one return track below. This viaduct extends 250 ft. to the dock line, and all five tracks are continued 1,300 ft. further into the stream upon a massive timber trestle, making a total length of about 1,850 ft., provided with chutes of the most improved pattern, with a variable mesh for use with different sizes of coal.

The cars are delivered by gravity from side tracks at the foot of the incline, and are drawn by endless rope and steam power to the summit of the latter, where they pass over the scales, which register their weight without arresting their motion. From the head of the incline to a point near the outer end of the timber trestle, about 900 ft., there is a descending grade of 1.4 per cent., and the impetus given by this grade is sufficient to carry the loaded cars around the 40° curves of all turnouts and cross-overs to the chutes, and to carry the light cars up a short incline at the outer end, where they retain sufficient impetus to start down the return track, which is located centrally between the others, with a grade of 3 per cent. This ends in a side track on the surface, connecting with the main tracks of the West Shore and the Erie railroads. Thus, by the use of grades only, no other power is needed from the time when the loaded cars pass the head of the incline until the light cars are in position to couple and pull out in a train for the mines. All switches work automatically, and that at the outer end, connecting the four east-bound tracks with the return track, designed by Mr. R. H. Brown, of the Delaware & Hudson Canal Company, serves its purpose particularly well in economizing room, which is of material value in a structure of this size.

On this trestle 8,000 tons of coal can be handled in a day, and it is considered an example of the best ideas yet evolved in this kind of structure.

The iron viaduct was built by the Rochester Bridge & Iron Works, and the general design prepared in accordance with the views of Mr. S. S. Smith, Superintendent.

The total cost of the work has been about $200,000.

Marine Engineering.

THE John Roach Company at Chester, Pa., has recently laid the keel of a new steamship for the Ocean Steamship Company, of Savannah. The new vessel will be named the *City of Birmingham*, and will be 230 ft. long, 42½ ft. beam and 16½ ft. deep, with a carrying capacity of 2,300 tons.

THE Iowa Iron Company at Dubuque, Ia., is to build a steel steamboat for St. Louis parties ; it will be the first steel boat on the Upper Mississippi. This boat will be 220 ft. long, 34 ft. beam and 5½ ft. hold. The engines will have two cylinders 17 in. diameter and 7-ft. stroke ; the stern-wheel is to be 20 ft. diameter and 24 ft. bucket. There will be three boilers 40 in. diameter and 26 ft. long, with two 14-in. flues. The boat is intended to be faster than any boat now on the river.

THE Hoboken Land & Improvement Company has had plans prepared for a new steel boat for its ferry between Hoboken and New York. The boat will be 200 ft. long and 37 ft. beam, and will be driven by a propeller at each end. This will be entirely a new departure in Hudson River ferry-boats, as they are now, without exception, side-wheel boats. The new boat will be fitted up in the usual style and will cost over $100,000.

THE Globe Iron Works in Cleveland, O., launched on February 29 the steel steamer *E. P. Wilbur*, built for the Lehigh Valley Company's line between Buffalo and Chicago. The vessel is 290 ft. keel, 308 ft. long over all, 40 ft. beam and 25½ ft. deep ; her carrying capacity is 2,650 tons. This is the largest vessel ever launched in Cleveland and will cost, complete, about $250,000. The engines are of the triple-expansion type, with cylinders 24 in., 38 in., and 61 in. diameter and 42-in. stroke, and will work up to 1,200 indicated H.P. Steam will be furnished by three boilers, each 11 ft. 10 in. diameter and 12 ft. long ; the working pressure will be 160 lbs. The propeller wheel is 14 ft. diameter and 17 ft. pitch. The Globe Iron Works have three sets of stocks, and from one of these three vessels have been launched inside of 13 months.

Car Heating.

THE Delaware & Hudson Canal Company has been recently using the Sewall system of steam heating on a train on its Pennsylvania Division, running between Carbondale and Wilkesbarre.

THE Erie Car Heating Company, which was recently organized at Erie, Pa., has its system of steam heating on trial on the West Shore, the New York, Chicago & St. Louis, the Lake Shore & Michigan Southern, and the Pittsburgh, Fort Wayne & Chicago roads. On the Fort Wayne road it has been in use on a local train running out of Pittsburgh for two years with much success.

WILLIAM BERRIGAN and Edwin K. Hanley, of Elmira, N. Y., have invented a system of heating trains by hot air. An air-pump on the locomotive forces air through a coil of pipes in the smoke-box, whence it passes through proper pipes and couplings to the cars. Each car is supplied with three hot-air reservoirs, placed under the floor, and communicating with the car through registers, by which the admission of heat to the car can be regulated. Safety-valves are attached to the reservoirs to prevent the pressure from becoming too great when the registers are closed. The inventors claim that the same system of pipes

and the air-pump can be used to supply a current of cool air in the summer. It is said that this system will be tried on a train on the New York, Lake Erie & Western Railroad.

Manufacturing Notes.

RIEHLE BROTHERS, manufacturers of scales and testing machines, have removed their office and warerooms from No. 50 South Fourth Street to No. 413 Market Street, Philadelphia, Pa.

THE Railroad Commissioner of Michigan has given official notice that he has examined and approved the Janney and the Dowling freight-car couplers, and that the use of those couplers is now authorized on the railroads of the State, under the law.

THE Lansing Iron & Engine Works, in Lansing, Mich., have completed a new building, 258 by 45 ft., and three stories high. The works are doing a large business fitting out sawmills and supplying engine and mill machinery.

THE Industrial Works in Bay City, Mich., have recently shipped steam pile drivers to the Minnesota & Northwestern and to the Panama Railroad; steam shovels to the Michigan Central and a double 15-ton wrecking car to the Chicago, Rock Island & Pacific. They are also building four turn-tables for the last-named road.

THE Sheffield Velocipede Car Company at Three Rivers, Mich., notwithstanding a fire which destroyed several of its buildings, is actively at work. It is now erecting a roughing-out shop, 48 by 48 ft.; paint shop, 100 by 48 ft.; erecting shop, 108 by 60 ft., and an addition to the machine shop, 112 by 60 ft. These new buildings will make the shops larger than ever before.

A NEW company is to be organized for the manufacture of steel tires; the works will be at Grapeville, Pa., 27 miles east of Pittsburgh.

THE Britton Iron Works in Cleveland, O., which were partially destroyed by fire a short time ago, have been rebuilt, and are now running to their full capacity.

THE Cleveland Machine Company has removed its drop-forging business from Cleveland, O., to Chicago, and has transferred its other business to the Cleveland Machinery Company, its successor.

THE Volker & Felthousen Manufacturing Company in Buffalo, N. Y., has recently closed contracts for pumping machinery for water-works at Pine Bluff, Ark.; Jamestown, N. Y.; Owensboro, Ky.; David City and Stromsburg, Neb. The works are running overtime.

FRAZER & JONES, of the Syracuse Steel Foundry, have just put in operation their new works in Syracuse, N. Y., the capacity of which is about three tons per day of mild crucible steel castings. At these works last year over 500 locomotive cross-heads were made.

THE Phœnix Iron Works in Cleveland, O., are furnishing plant for the new pipe works of the Steel Company of Canada at Londonderry, N. S. This comprises one 10-ton steam-power crane and six hand-power cranes. The 10-ton crane is entirely of iron.

IN pursuance of the plan adopted some time ago, H. K. Porter & Company, in Pittsburgh, recently distributed among the employés of their works a share of the profits of the past year. The amount was about $15,000, and the individual shares varied from $2 to $300, according to rate of wages and length of service.

THE Wrought-Iron Bridge Company in Canton, O., is building a highway bridge over the Mississippi River between St. Paul and Minneapolis, Minn. There are two channel spans of 456 ft. each and several shorter spans, the entire length of the bridge being 1,273 ft. The contract price is $109,000, and it is to be finished by August next.

THE King Iron Bridge & Manufacturing Company in Cleveland, O., is building a new shop near the present one. It will be finished in June next and will be fitted up with the most approved machinery for iron and steel bridge and structural work. When this new shop is ready for use the company will be able to turn out 1,600 tons a month of finished work.

THE Home Electric Light Company in Oswego, N. Y., is introducing the Edison three-wire system of lighting into that city. The incandescent light plant will be run by a 90 H.P. Tonkin close-throttling engine, which, with the boilers, has been furnished by the T. Kingsford Foundry & Machine Works, of Oswego. A Tonkin high-speed, automatic cut-off engine of 300 H.P. will be used to run the street-lighting plant; for this the Remington dynamo and lamp will be used. Mr. F. J. Fisk has charge of the work.

THE Toledo Foundry & Machine Company in Toledo, O., recently closed a contract for a "Victor" railroad excavator for the Seattle, Lake Shore & Eastern Railroad Company in Washington Territory; also for another (the second furnished) for the Pennsylvania Railroad Company. One of this company's canal ditching machines was recently sent to the Kearney Canal & Water Supply Company in Nebraska.

IN the Lehigh Valley shops at Packerton, Pa., there was recently built a flat car of 120,000 lbs. capacity. This was made for the special purpose of carrying some heavy machinery from Perth Amboy to Bethlehem, Pa., for the Bethlehem Iron Company. The platform is 37 ft. long and 8 ft. wide. The car weighs 45,500 lbs., the trucks being 23,800 lbs. and the body 21,700 lbs. There are four intermediate sills 12 in. by $4\frac{1}{2}$ in., and two side-sills of same dimensions, all of yellow pine and framed in channel beams. The body bolsters are made from channel beams and trussed by eight $1\frac{1}{4}$ in. rods and four $1\frac{1}{4}$ in. rods. The end-sills are of oak, 10×12 in., framed with wrought-iron plates, $8 \times \frac{1}{2}$ in., used as compression plates for truss rods. There are two trussed oak needle-beams in center. The car is carried on two six-wheel trucks, with 33-in. steel-tired wheels. The axles have journals 5 in. diameter and 9 in. long.

Proceedings of Societies.

National Electric Light Association.

THE seventh meeting of the National Electric Light Association was held at the Monongahela House in Pittsburgh. The first session began at noon on Tuesday, February 21, when the Convention was called to order by President J. Frank Morrison, who delivered a brief address on the Progress of Electric Lighting.

The Secretary then presented a number of communications and invitations, which were properly referred. The reports of the Secretary, the Treasurer, and the Executive Committee were presented and approved.

Professor F. Forbes, of London, England, was elected an honorary member.

The report of the Committee on the Insulation of Wires and Construction of Plant was read by the Secretary, and an elaborate paper on the same subject by Professor E. Thomson was also read; a brief discussion followed.

A paper by Dr. P. Lange, on the Protection of Watches against the Influence of Magnetism, was then read and discussed.

In the evening the members attended, by invitation, a meeting and reception of the Engineers' Society of Western Pennsylvania.

On the second day, February 22, at the morning session the report of the Legal Committee on the Importance of the Patent Laws was read and discussed; the committee was continued. Professor E. L. Nichols, of Cornell University, was elected an honorary member.

A paper on Leather Belting, giving an account of the recent improvements in its construction, was read by C. A. Schieren, of New York, and was briefly discussed.

At the afternoon session Dr. G. A. Liebig read an elaborate paper on Electric Motors, which called out an interesting discussion.

Mr. W. Lee Church then read a paper on Independent Engines for Incandescent Light Stations, in which he showed the necessity of making a careful choice of motive power for such stations, and enumerated the qualities which the engine for this purpose should possess.

Mr. Jarvis B. Edson then read a paper on the Economic Value of Steam Pressure Records, which was followed by a discussion.

Mr. S. E. Barden read a paper on the Relation of Electric Lighting to Fire Insurance, and G. W. Parker, of St. Louis, read one on the Qualities Constituting a Good Carbon Point.

On the third day some amendments to the Constitution were discussed and laid over until the next meeting.

The following papers were read: Distribution of Electricity by Alternate Currents, by T. C. Smith; the Energy of Alternating Currents, by O. B. Shallenberger; the Undergrounding of Electric Arc Light Wires, by W. W. Leggett; Underground Conductors for Electric Currents, by J. M. Smith. These papers were followed by a discussion on Underground Wires, which was not concluded until the afternoon session.

At the closing session a special committee was appointed on the Revision of the Constitution. It was decided to hold the next meeting in New York.

The usual resolutions, etc., were passed, and the following officers were elected for the ensuing year: President, S. A. Duncan, Pittsburgh; First Vice-President, E. R. Weeks, Kansas City; Second Vice-President, A. J. DeCamp, Philadelphia. Executive Committee, Dr. Otto A. Moses, Chairman; J. Frank Morrison, Baltimore; E. T. Lynch, Jr., New York; Frank Ridlon, Boston; T. C. Smith, Pittsburgh; E. F. Peck, Brooklyn.

American Institute of Mining Engineers.

The annual meeting began at the Hotel Brunswick, in Boston, February 21. General Francis A. Walker, President of the Massachusetts Institute of Technology, made an address of welcome, to which President Eggleston made an appropriate answer.

Papers were then read on Spirally Welded Tubing, by J. C. Bayles; New York Mining Law, by Professor R. W. Raymond; Recent Mining Accidents, by Charles A. Ashburner.

On the second day a long session was held for the reading of papers; those presented were as follows: The Topography and Geology of the Cerro di Pasco, Peru, by A. D. Hodges; the Formation of Fissure Veins, by S. F. Emmons; Recent Developments in the Open Hearth Process, by Alfred E. Hunt; Applications of Electricity to Mining, by G. W. Mansfield; the Bofors Steel Gun, by Captain O. E. Michaelis; the Husgafvel Improved High Bloomary for producing iron and steel direct from the ore, by F. L. Garrison.

The paper on Recent Mining Accidents was discussed by a number of members.

In the evening the annual dinner of the Institute was eaten, a large number of the members and guests being present.

February 23, the members of the Association went to Fitchburg, by special train, visiting the works of the Putnam Machine Company, the Fitchburg Steam-Engine Company, and the Simonds Rolling Mill Company; they also visited the works of the Waltham Watch Company, at Waltham.

In the evening a session was held at which papers were read on the Phosphates of the Ottawa Valley, by Robert Bell, and on the Plant of the Boston Heating Company, by A. V. Abbott; the last paper was discussed.

February 24, a greater part of the day was spent in visits to points of interest in Boston and vicinity. In the evening a business meeting was held, at which the reports of the Council and the officers of the Institute were presented and approved. The tellers announced the election, by letter-ballot, of the following officers for the ensuing year: President, Professor W. B. Potter, St. Louis; Vice-Presidents, J. C. Bayles, New York; Alfred E. Hunt, Pittsburgh, and T. Sterry Hunt, Montreal; Managers, Robert Forsyth, Chicago; Kenneth Robertson, Birmingham, Ala., and Charles M. Rolker, New York; Treasurer, Theodore D. Rand, Philadelphia; Secretary, R. W. Raymond, New York.

Western Railway Club.

The regular monthly meeting was held in Chicago, February 15. Mr. E. M. Herr read a paper on the effects of Magnetism on Watches; this was discussed by Messrs. Gibbs, Herr, Sinclair, and W. A. Smith.

The subject of Axles for 60,000-lbs. Cars was then taken up, and was discussed by Messrs. Hickey, Verbryck, Mackenzie, Nichols, and Forsyth; all of the speakers advocated heavy axles, but no decision was reached, and the subject was continued until the next meeting.

The third subject for the meeting was Six-Wheel Trucks Under Heavy Freight Cars, and this was also postponed until the next meeting.

Southern Society of Civil Engineers.

The thirteenth regular meeting was held recently at Jacksonville, Fla. Discussions on Drainage and Land Reclamation followed the regular order of business. The membership of the Society is rapidly increasing.

The following were elected officers for 1888: President, H. S. Duval, State Engineer of Florida; Vice-Presidents, Louis J. Barbot, J. E. Bozeman, M. L. Lynch, J. G. Mann, and T. R. Dunn; Treasurer, J. W. Bushnell; Secretary, T. S. Moorhead, Jacksonville, Fla.; Directors, R. N. Ellis, C. F. Smith, J. G. Gibbs, P. W. O. Koerner, and A. Bauer; Committee on National Public Works, Louis J. Barbot, N. E. Farrell, and T. S. Moorhead.

New England Railroad Club.

The annual meeting was held in Boston, March 14. The Secretary and Treasurer, Francis M. Curtis, read his annual report, showing the receipts of the year to have been $533, the expenditures $366, and balance on hand $167. There are 193 members, and the average attendance at the monthly meetings has been 64.

The Committee on Nominations reported the following list of officers for the ensuing year: President, James N. Lauder; Vice-President, George Richards; Secretary and Treasurer, F. M. Curtis; Executive Committee, J. N. Lauder, F. D. Adams, J. K. Taylor, J. W. Marden, Osgood Bradley, A. M. Waitt, Albert Griggs, J. T. Gordon, J. A. Coleman; Finance Committee, James Smith, Chairman, Isaac N. Keith, Robert Johnson, Charles Richardson, Joel Hill, A. G. Barber, David S. Page, George Draper. The report was accepted and adopted unanimously. President Lauder returned his thanks for his re-election, and stated that, his belief being that no man should hold office more than two years, he should not under any circumstances accept the office after this year.

The topic for discussion, continued from the previous meeting, Wheels and Axles, and their Relation to the Track, was taken up.

Professor C. F. Allen read a carefully prepared article, giving interesting statistics of the failures of wheels and axles on English railroads. The standard passenger wheel on English roads is a steel-tired one, but its excellence was claimed not to be due wholly to the fact that it is steel-tired, but to the general excellence of the wheel. Professor Allen expressed regret that the record of wheels in this country is not complete enough to base any conclusions upon.

Vice-President Richards stated that the wooden wheel referred to by Professor Allen is filled in from the tire to the hub with teak. Some of the wheels were tried some years ago on the Boston & Albany Railroad.

Mr. Adams said they were tried, but the climate was too much for them, the wood shrinking badly. Another experiment with the same wheel is being tried, and 16 of the wheels are now in service. Thus far they have done fairly well, but Mr. Adams is afraid the experiment will result about the same. The road is using steel-tired wheels, and during 17 years not a life has been lost by their breaking, though some have been discovered to be broken in season to take them out before any accident resulted. It has been several years since any wheels have broken until this winter, which has been unusually severe on wheels. It is very important to properly secure the tires on the wheels, though some persons might claim it would be better to have the entire wheel steel. The road has an almost absolutely correct manner of keeping a record of the mileage of all the wheels.

Mr. Coleman said, in considering the safety of wheels compared with those on English roads, the difference in climate and the superior excellence of the roads in that country should be considered.

Mr. Whitney coincided with the views of previous speakers regarding wooden wheels and the different conditions of climate and roadbed in this country compared with those in England. Notwithstanding those conditions, however, he thought if they would send good, honest wheels to this country, they would do as good service as on English roads.

Mr. Coleman contended that an iron wheel with a steel tire shrunk on it is bound to come to grief. He declared the same vicious system is in use in England in making cannon, and he believed that the entire armament of England will fail when brought to the actual test of war.

President Lauder said the breaking of tires on the driving-wheels of locomotives is very seldom seen.

Vice-President Richards described by means of a diagram on the blackboard the construction of wheels, and explained some of the causes of their failing.

Mr. Adams asserted that the most prolific cause of breaking of wheels is the splitting of steel tires occasioned by imperfections in the steel. He has known of very few instances where wheels have broken longitudinally. He knew of one case where the tire split entirely around.

Mr. Ellis called attention to the fact that English wheels are

much larger than those in use in this country. He spoke of the wooden wheels now made in England as showing greatly improved construction over those formerly made, and claimed they have been used in Germany and other countries to advantage.

Professor Swain spoke of the comparative cost of different kinds of wheels. The true way of comparing the cost of wheels is to see how much capital it would take to purchase the wheel and to return it, and the amount that would be obtained for it when worn out. He presented various figures as examples of this method of comparison.

The discussion continued for some time longer, a number of gentlemen participating.

American Society of Civil Engineers.

A REGULAR meeting was held at the Society's House in New York, March 7, Mr. Mendes Cohen in the chair. The Secretary read the decisions of the committees examining prize essays, who awarded the Norman Medal to the paper on Evaporation, presented by Desmond Fitz Gerald, and the Roland Prize to the paper on Steel, some of its Properties, its Use in Structures and in Heavy Guns, by William Metcalf.

The Secretary then read a paper by John W. Hill, on Tests of an Edison Incandescent Electric Lighting Plant. The paper was a very full description, report, and tabulation of an elaborate eight days' working test of the cost, efficiency, and relative value, compared with gas, of the Edison plant in the Union Central Depot at Cincinnati, O. Mr. Hill found that, considering the actual illuminations compared, that of the electric lamps cost 39 per cent. more than the gas-light. He considered that the results of the tests indicated so great a loss of power between the engines and dynamos, that electricians should be stimulated to remedy it. The paper was discussed by Messrs. Flagg and Howell.

The tellers announced the result of the votes on amendments to the Constitution as follows: The amendment establishing a new student grade was lost by 137 affirmative to 142 negative.

The amendment providing for election of members by committee was lost by 67 affirmative to 212 negative.

The other proposed amendments relative to admission of foreign applicants and reconsideration of ballots were carried by votes of 251 and 226 affirmative to 32 and 55 negative respectively.

Elections were announced by the tellers as follows:

Members: Frederick James Amweg, Philadelphia; Oberlin Matthies Carter, Savannah, Ga.; Charles Sewall Gowen, Sing Sing, N. Y.; Charles Davis Jameson, New York; Edward John Landor, Canton, O.; Hunter McDonald, New Market, Ala.; George Romaine Olney, Morris Dock, N. Y.; Francis Ensor Prendergast, Newton Highlands, Mass.; George Henry Robinson, Marysville, Mon.; Edward Wegmann, Jr., Englewood, N. J.; Arthur Owen Wilson, Birmingham, Ala; John Young, Geneseo, N. Y.

Associate: John Haines Warder, Wilmington, Del.

Juniors: David Sylvanus Carll, Kansas City, Mo.; Charles Alfred Hasbrouck, Detroit, Mich.

Master Mechanics' Association.

THE following circular has been issued by Secretary Angus Sinclair from his office, No. 175 Dearborn Street, Chicago:

MAGNETIC INFLUENCE OF IRON AND STEEL IN LOCOMOTIVES ON THE WATCHES OF ENGINE RUNNERS.

1. Have you noticed any variation in the running of your watch on or off your engine?
2. Have you noticed any variation in the running of your watch when in your regular daily employment, and when off one or more days?
3. Have you noticed any difference in the rate of your watch between summer and winter months?
4. Does the main spring of your watch break frequently?
5. How many times have you had a new main spring in your watch?
6. At what season of the year does the main spring break most frequently?
7. Have you noticed any coincidence of storms and breaking of main springs?
8. Have you noticed that the main spring would be broken after a thunder storm, or an electric disturbance of the atmosphere?
9. Do you compare your watch with the standard time daily?
10. Do you note the variation of the watch with the standard time absolutely, down to a second?
11. Do you set your watch when it is a little "off" time, or do you carry the variation in your mind?
12. Have you ever noticed any difference between the average running of watches carried by engineers and conductors?

Answers should not be confined to the above questions, but should include any information or suggestions that would be valuable to the Committee.

JAMES MEEHAN,
HARVEY MIDDLETON,
T. W. GENTRY,
Committee.

Replies to be addressed to James Meehan, Cincinnati, New Orleans & Texas Pacific Railroad, Ludlow, Kentucky.

Master Car-Builders' Association.

THE following Committee circular has been issued from the office of the Secretary, No. 45 Broadway, New York, under date of March 20:

JOURNAL LUBRICATION AND THE BEST PRACTICE FOR ECONOMIZING OIL.

The undersigned Committee, appointed to consider this question and report at the Convention to be held in June, 1888, desires information on the following questions:

1. What kind of oil or grease do you use for lubricating journals of passenger cars?
2. What kind for freight cars?
3. Have you made any tests to determine the relative cost of lubricating journals with pure petroleum and with mixtures of petroleum and animal oils? If so, please give conclusions.
4. Have you experimented with any form of dust guard other than the M. C. B. standard? If so, and you have secured satisfactory results, please send drawings of the dust-guard.
5. What are your views as to the best methods to be pursued for the purpose of economizing oil in lubrication of car journals?

Please address your replies to this circular to J. W. Cloud, Buffalo, N. Y.

J. W. CLOUD,
H. ROBERTS, } Committee.
J. N. LAUDER,

Boston Society of Civil Engineers.

A REGULAR meeting was held at the rooms in Boston, February 15, President Rice in the chair. Joseph Coulson, Jr., C. Atherton Hicks, and John H. Webster were elected members, and seven names proposed for membership.

A letter from Mr. E. L. Corthell, of Chicago, member of the Society, was read in relation to the work of the Council of Engineering Societies on National Public Works, and referred to the Committee on National Public Works.

Mr. Henry Manley was appointed a committee to arrange for the annual dinner, and the usual appropriation was made for the same.

A committee, consisting of Messrs. F. P. Stearns, F. L. Fuller, and Frederick Brooks, was appointed to nominate officers for the ensuing year.

Mr. Frederick Brooks read the paper of the evening, entitled Sewage Disposal at Medfield, Mass.

Mr. Wilbur F. Learned also read an account of experiments made by him in the chemical treatment of the sewage at Mystic Lake.

Civil Engineers' Society of St. Paul.

AT the regular meeting, in St. Paul, Minn., February 13, a number of applications for membership were received. A committee upon rooms was appointed to make arrangements for the meetings of the ensuing year. It was resolved to have the duplicate volumes of the Journal of the Association on Engineering Societies, now in possession of the Society, bound and to present the same to the St. Paul Public Library.

Letters from Mr. J. A. L. Waddell were read relative to introducing his pamphlet on Standard Specifications for Iron Bridges; they were referred to a special committee to report at the next meeting.

The President of the Society read a paper which was a report to the Council of Engineering Societies upon the methods at

present employed in conducting public works in France and Germany.

OBITUARY.

CHARLES THEODORE PIERSON, who died in New York February 24, was for many years prominent in the iron trade in that city. He was connected with the management of the Ramapo Car Works and other manufacturing concerns. He was Receiver of the Grant Locomotive Works in Paterson some years ago, and aided materially in settling the affairs of that company.

W. W. HANSCOM, who died in San Francisco January 16, aged 48 years, was a mechanical engineer well known on the Pacific coast. He was connected with the construction of the cable railroad system in San Francisco, and was a strong advocate of the cable plan for street railroad traction. He was also connected with some cable road work in England. Mr. Hanscom invented a system of train brakes, which was one of those tried at the Burlington brake tests last year.

STURGIS MEEK, who died at Dunstall, England, February 16, aged 71 years, was one of the last survivors of the older generation of English engineers. He was a pupil of George Stephenson, and began work under him in 1833 on the construction of the London & Birmingham line. Later he was employed as a division engineer on the Paris & Rouen Railroad in France, and on the Dutch-Rhenish line in Holland, and as Assistant Engineer to Mr. Locke on the Great Northern Railway in England. In 1846 he was employed on the construction of the Midland Railway, and in 1853 he was appointed Engineer of the Lancashire & Yorkshire. Some years later he became Engineer-in-Chief of that company, and retained that position until his death. Mr. Meek had a high reputation as a locating engineer, and was also an authority on almost all questions relating to maintenance of way.

ENSIGN BENNETT, who died in Buffalo, N. Y., February 21, was born in Chautauqua County, N. Y., in 1831, and at an early age became a civil engineer. He was employed as assistant engineer on the old Cleveland, Painesville & Ashtabula road and afterward in the office of the City Engineer of Buffalo, and as Resident Engineer on the Erie Canal. In 1861 he entered the Government service, and was employed in building fortifications at various points. In 1864 he went to Indiana, and was concerned in several extensive contracts for building railroads. He returned to New York in 1875 and settled in Rochester. He built the Genesee Valley road, in which he was largely interested. In 1882 he removed to Buffalo, and took the management of the Fairmount Coal Company and other large coal interests, which he retained until his death.

JEAN BAPTISTE ANDRE GODIN, who died at Guise, France, in February, was widely known from his efforts to build up the co-operative principle both in manufacturing and living. Born a poor man, he built up, mainly by his business tact and his inventive genius, a large foundry business, employing a great number of workmen. In 1859 he planned the "Familistiere" or "Social Palace," as a home or dwelling-place on the social co-operative plan for all his employés. The plans were carried out as he desired, although the great buildings, owing to constant additions and the continual growth of the plans, were not finally completed for over 20 years. One of M. Godin's most prominent ideas was the importance of education, and so highly did he esteem it, that in the arrangement of the co-operative plans the cost of the schools was made a first charge, before any distribution of profits could be made.

The "Familistiere" attracted wide attention not only in France but in other countries, and many descriptions of it were published. To defend his plans from criticisms which were made, and to extend his ideas, M. Godin became an author. In 1871 he published the important work called "Solutions Sociales," and later the following four treatises, called: "La Richesse au Service du Peuple," "Les Socialistes et les Droits du Travail," "La Politique du Travail, et la Politique des Privileges," "La Souverainte et les Droits du Peuple." In 1878 he began to issue, as a means of propaganda for the social and associated political reforms which he desired, the weekly organ *Le Devoir*, to which he contributed a large portion of the most important articles. In 1881 appeared an elaborate treatise on the true principles and form of government ("Le Gouvernement") which, with "Les Solutions Sociales," constitute his chief works.

While opinions may differ as to the practicability of all M. Godin's ideas, and the possibility of applying them in countries where the conditions of life are different from those in France, he deserves the credit of making the first intelligent and successful effort to introduce the co-operative principle on a large scale.

THOMAS J. POTTER, who died in Washington March 9, was one of the best known and most successful railroad managers in the Northwest. He had been suffering for some time from a complication of diseases, and had been taken to Washington from Omaha, in the hope that a change of climate might prove beneficial. He was born in Carroll County, O., in 1840, and after working at various occupations as a boy, went to Iowa in 1862, and had his first railroad experience as lineman in an engineer corps on the Burlington & Missouri River Railroad. He soon left to enter the army; after the war he was a storekeeper for a time, but in 1866 went back to the Burlington & Missouri River road as station agent at Albia, and two years later was made Fuel and Claim Agent for the road. When the road became part of the Chicago, Burlington & Quincy system he was appointed General Agent at Creston, then Assistant Superintendent, and in 1875 Superintendent of the Iowa Division.

Mr. Potter was now in a position where his ability as a manager could be recognized, and his promotion was rapid. In 1878 he was made General Superintendent, in 1879 Assistant General Manager, and in 1880 General Manager of the road. From 1884 until about a year ago he was Vice-President and General Manager of the company. In May, 1887, he was appointed First Vice-President of the Union Pacific Company, with charge of the operation of all that company's lines. The work required to reorganize the management of that complicated system and to put it upon a proper basis was too much for him, and his health broke down some months ago. He was a man of strong character and excellent judgment, and his services were highly appreciated, as shown by the positions to which he attained. One of his most prominent characteristics was his promptness in deciding the questions which came before him, for he was one of those men whose first judgment was the best, and who did not have to wait for the second thought. With no influence to help him, he rose from the ranks by the force of his own abilities, and he always retained a kindly feeling for his old comrades.

ANDREW J. STEVENS died in Sacramento, Cal., February 11, aged 54 years. He was born in Barnard, Vt., and learned the trade of a machinist in the shops of the Northern Railroad at Concord, N. H. After working on that road and on the Vermont Central for a few years he went West, and was for seven years on the Chicago, Burlington & Quincy, part of the time as Foreman in the repair shops at Aurora, Ill. In 1861 he went to California, and after short terms of service on the Market Street Railroad and at the Vulcan Iron Works in San Francisco, he became Superintendent and Master Mechanic on the old San Francisco, Oakland & Alameda Railroad. When that road was absorbed by the Central Pacific he was made Division Master Mechanic; in 1870 he was promoted to be General Master Mechanic of the Central Pacific, holding that position until the road was leased to the Southern Pacific Company, when he was made General Master Mechanic of all the lines operated by that company. Mr. Stevens was a man of very active mind, and was continually engaged in devising improvements in construction. Among his more prominent improvements in locomotives were the Stevens steam packing for pistons, a balanced valve, and the Stevens valve motion with independent cut-off.

The Central Pacific built many of its own locomotives in its shops at Sacramento, and all of these were designed by Mr. Stevens, who brought into use many new devices of his own and others. Some years ago he built at these shops *El Gobernador*, which was designed for special service over the heavy grades of the Tehachapi Pass on the Southern Pacific, and which was at that time the largest locomotive in the world; and it has, indeed, been only exceeded in size by two or three others since built.

The Central Pacific, besides its rolling stock on land, owns a large fleet of ferry-boats and river steamers, and the machinery of these vessels was also under Mr. Stevens's charge. He built the machinery of a number of boats, and, as in the locomotive department, he introduced many improvements; among these was a steam-steering apparatus, which is now widely used. He designed and built the machinery of the *Piedmont*, the *Modoc*, the *Apache*, and other large boats, and also the engines and boil-

ers for the *Solano*, the largest ferry-boat ever built; he also designed and built the machinery for operating the ferry slips and landing stages at Oakland and San Francisco. The extensive shops at Sacramento and their machinery were also largely of his designing.

Mr. Stevens was highly esteemed by his subordinate officers and the men under his charge; while a strict disciplinarian and careful manager, he took much interest in his men, and always encouraged those who were anxious to advance. He was also highly esteemed in the community where he resided as a useful and public-spirited citizen. He leaves a wife, daughter, and one son.

WILLIAM KELLY, who died in Louisville, Ky., February 11, aged 76 years, had a fair claim to the original invention of the Bessemer process for making steel. He was born in Pittsburgh, and was for several years engaged in the transportation and steamboat business. In 1845 he removed to Kentucky, and engaged in the manufacture of iron at the Suwanee Furnace and Union Forge in Lynn County. Here he began to introduce improvements, and commenced a series of experiments in the direction of decarbonizing the iron by the introduction of a current of air into the melted metal from the furnace. These experiments he continued for several years, with varying success, not wishing to make his process public until he had perfected it.

The following statement of his later action is taken from the *Iron Age*: "As soon as Bessemer brought out his process in England Mr. Kelly at once applied for a patent, and placed the matter in the hands of a well-known patent firm, who, it is claimed, retained the papers long enough to inform Mr. Bessemer and allow him to get out his patent, after which they notified Mr. Kelly that they had been engaged by other parties to obtain a patent for the same invention. However, a caveat was granted by the Patent Office, and the claim of Mr. Kelly was duly heard by the Commissioner, who decided that Mr. Kelly was the first inventor, and entitled to a patent, which was accordingly issued. In May, 1863, E. B. Ward, of Detroit, Mich., Daniel J. Morrell, of Johnstown, Pa., William M. Lyon and James Park, Jr., of Pittsburgh, Pa., and Zoheth S. Durfee, of New Bedford, obtained control of the patent of Mr. Kelly, and organized the Kelly Process Company, under an agreement which gave the inventor and his representatives an interest, which has been valuable. Experimental works were established at Wyandotte, Mich., and Mr. Durfee was sent to England to procure an assignment of Robert F. Mushet's patents, which had been found essential to the success of the process. This purpose having been accomplished, Mr. Mushet, Thomas D. Clare, and John N. Brown, of England, were admitted to membership in the company.

"In the autumn of 1864 Mr. William F. Durfee succeeded in making, at his experimental works at Wyandotte, the first steel ingots ever made by the pneumatic process in the United States; and on May 25, 1865, the first steel rails ever made in the United States were rolled from steel ingots. Meanwhile Alexander L. Holley had, in the interest of John F. Winslow and John A. Griswold, of Troy, N. Y., secured the patents of Henry Bessemer for the United States, but without the use of Mushet's patents they could not successfully produce steel; and, on the other hand, the Bessemer machinery was essential to the Kelly process. Therefore, in 1866, the interests of the several patentees were consolidated under the title of the Pneumatic Steel Association.

"Application was made at the United States Patent Office, in 1871, for the renewal of the Bessemer, Mushet, and Kelly patents, and the claims of the two former were rejected, while a renewal of seven years was granted to Mr. Kelly, it having been shown that he had not been sufficiently remunerated, having only received about $30,000 for the use of his patent, against $25,000 expenditures."

PERSONALS.

J. M. JOHNSON has been appointed Chief Engineer of the Louisville Bridge & Iron Company, succeeding Gilman Trafton, deceased.

R. MONTFORT, for some years past Resident Engineer of the Louisville & Nashville Railroad, has been appointed Chief Engineer. That office has been vacant for several years.

R. E. RICKER has been appointed Superintendent of the Iron Mountain, the Little Rock & Fort Smith, and the Texas lines of the Missouri Pacific Company. He was recently on the Denver & Rio Grande, and was for a number of years on the Central Railroad of New Jersey.

ONWARD BATES is now Engineer and Superintendent of Bridges and Buildings of the Chicago, Milwaukee & St. Paul road, with office in Milwaukee.

JOHN ORTTON has resigned his position as Master Mechanic of the Eastern Division of the New York Central & Hudson River Railroad, which he has held with much success for several years past. Mr. Ortton has had many years' experience in England, Canada and the United States, and is a master mechanic of high standing in his profession. He has not yet decided on his future location.

J. M. LOWRY, for some time past General Master Mechanic of the Chicago, Milwaukee & St. Paul road, has been retired from that position at his own request, but remains with the company as Consulting Engineer of the Machinery Department.

WILLIAM SMITH, Superintendent of Motive Power and Machinery of the Boston & Maine Railroad, has had his jurisdiction extended over all the lines operated by the company, including the Boston & Lowell system.

D. C. RICHARDSON is now Master Car-Builder of the Boston & Maine Railroad and all its leased and controlled lines, and has his office at Lawrence, Mass. Mr. A. M. WAITT is Assistant Master Car-Builder, with office at Salem, Mass.

J. C. MUNRO was, on February 1 last, appointed Superintendent of Motive Power and Machinery of the Mexican National Railroad, with office at Laredo, Tex. His authority extends over all the divisions of the road, and all division master mechanics report to him.

S. H. HARRINGTON, for several years in charge of the drawing-room of the Pittsburgh, Cincinnati & St. Louis shops at Columbus, O., has been placed in charge of the drafting department of the New York, Pennsylvania & Ohio Railroad. Mr. Harrington is an active man, who has devised and introduced many improvements in construction.

MAJOR WILLIAM LUDLOW, late Engineer Commissioner of the District of Columbia, is now Engineer of the Fourth Lighthouse District, with station in Philadelphia.

PROFESSOR THOMAS GRAY, of the University of Glasgow, Scotland, has been appointed to the chair of dynamic engineering in the Rose Polytechnic Institute, Terre Haute, Ind., and has signified his acceptance of the position.

WILLIAM A. BALDWIN has resigned his position as Manager of the Pennsylvania Company's lines. He has been connected with the company for a number of years in various positions. Mr. Baldwin has accepted the position of Vice-President and General Manager of the Buffalo, Rochester & Pittsburgh Railroad.

LEWIS KISTLER has been appointed Master Mechanic of the Syracuse, Binghamton & New York and the Oswego & Syracuse divisions of the Delaware, Lackawanna & Western road, succeeding Mr. James Buchanan. He has been Foreman for several years.

JAMES BUCHANAN has been appointed Assistant Superintendent of Motive Power of the New York Central & Hudson River Railroad—a new office. He will have charge of the shops at West Albany. Mr. Buchanan has been for 14 years past on the Delaware, Lackawanna & Western road.

J. N. BARR has been appointed Superintendent of Motive Power of the Chicago, Milwaukee & St. Paul Railroad; he will have charge of the motive power and of the Car Department also. Mr. Barr has been for some time past Superintendent of the Car Department.

J. K. TAYLOR, Superintendent of Motive Power of the Boston & Lowell Railroad, resigned his position on February 29, in consequence of the lease of the road to the Boston & Maine. Mr. Taylor is well known in his department. He was at one time with the Manchester Locomotive Works, and afterward went to the Lake Shore road as Master Mechanic. More recently he was for several years Master Mechanic of the Old Colony Railroad; from that road he went to the Boston & Lowell.

NOTES AND NEWS.

Liquid Fuel for Steel Works.—The Union Steel Company, of Chicago, is putting into the steel works a liquid-fuel plant to use crude petroleum. Two 1,000-barrel tanks are being erected, into which the oil will be pumped from cars, and from which it will afterward be pumped as required into smaller tanks for use at the respective batteries of boilers. The officers of the Company hope to be able to use it not only under boilers, but to substitute it for gas in the soaking pits and reheating furnaces.

New Method of Sinking Wells.—The old method of sinking wells or shafts by a wooden crib surmounted by masonry walls is superseded of late in Belgium by the use of hollow cylindrical sections of cement tubing of the required diameter, smooth externally, with inside collars jointed with liquid cement. As the excavation proceeds sections of the tubing are added at the top until the required depth is obtained, when the opening is closed with a cement slab, having a man-hole in the center.—*La Semaine des Constructeurs.*

Anthracite Coal in India.—It is quite true that anthracite coal of most excellent quality has been discovered in the hills along the Pishin Valley route from Sibi to Quetta. There is one seam, about half a mile in length, appearing like a black line on the side of the hill close to the station of Nasik. Small quantities of the best quality of this coal can be purchased locally at Rs. 14 ($5) a ton.—*Indian Engineering.*

Blast Furnaces of the United States.—The *American Manufacturer* gives the condition of the blast furnaces on March 1 as follows:

Fuel.	In Blast. No.	In Blast. Weekly capacity.	Out of Blast. No.	Out of Blast. Weekly capacity.
Charcoal	62	11,713	111	13,316
Anthracite	102	29,066	98	26,277
Bituminous	129	76,800	85	45,239
Total	293	117,579	294	84,832

"There is a total in blast of 20 less than on February 1. Of this reduction, 8 are charcoal, 1 anthracite, and 11 bituminous. The weekly capacity of those in blast is 9,547 tons less than on February 1. Of this reduced capacity, 2,029 tons are at charcoal furnaces, 593 at anthracite, and 6,925 at bituminous."

On March 1, 1887, there were 349 furnaces in blast with a weekly capacity of 135,173 tons. The reduction this year, as compared with last, is thus 56 in the number of furnaces and 17,594 tons in the weekly capacity.

Electric Lighting in Forts.—The German Staff has recently adopted a system of electric lighting for forts, the luminous power of which is so great that it is stated that objects can be distinguished at night at a distance of 7½ miles. The details of the plan have been kept strictly secret. All the forts on the frontier are now being supplied with the plant, which is manufactured by Schuckert & Company, of Nuremberg.

One essential novelty of this apparatus is the use of parabolic mirrors as reflectors. The use of these mirrors, it is said, has made it possible to throw the light further than ever before.

French officers are now at work on the same question, the use of the electric light, and a system will shortly be adopted.

Accidents on Indian Railroads.—The returns for the three months ending June 30, 1887, give the number of persons killed and injured on the railroads of India as follows:

	Killed.	Injured.	Total.
Passengers	9	44	53
Employés	49	135	184
Others	57	20	77
Total	115	199	314

Of the passengers 9 were injured in train accidents; 9 were killed and 35 injured by falling from trains or in similar ways.

Nine employés were killed and 19 hurt in train accidents; 11 were killed and 23 injured in coupling cars. The rest were run over, fell from trains, etc.

Of the other persons 7 were killed and 5 hurt at grade crossings; 1 killed and 14 hurt while trespassing on the line, while no less than 49 are put down as suicides.

American Steel Production in 1887.—The *Bulletin* of the American Iron & Steel Association gives the following statement of the production of steel in the United States, in net tons:

	1887.	1886.
Bessemer	3,219,678	2,495,122
Clapp-Griffiths	68,679	46,371
Open-hearth	360,717	245,250
Crucible	84,421	80,609
Miscellaneous	6,265	2,651
Total	3,739,760	2,870,003

The increase last year over 1886 was thus 869,757 tons, or 31¼ per cent.

There were in operation during the year 34 Bessemer plants with 72 converters; 14 Clapp-Griffiths plants with 14 converters; 39 open-hearth plants.

The production of steel by various miscellaneous processes not included under the head of any above mentioned was 6,265 net tons, against 2,651 net tons in 1886. Most of this steel was made in Philadelphia and vicinity and in Pittsburgh.

The Beam Engine for Steamboats.—All the steamboats running on the Hudson River previous to 1824 belonged to the North River Line or Fulton & Livingston's Line, holding the monopoly of the water of New York State, and had "Square" engines. After the U. S. Supreme Court removed all barriers to the free navigation of the water of the State, in 1824, there were many opposition lines started, but none of the steamboats had beam engines until Robert L. Stevens, of Hoboken, N. J., placed on the river, in 1827, the *Albany*, the *North America*, and the *New Philadelphia*, all of which had that type of engine, the *North America* having a pair with cylinders 44 in. diameter and 8 ft. stroke, while the other two had single engines. It is more than probable that the *Albany*, built in 1826, was the first to run to Albany from New York of the three.

A few years previous to this date there were two or three ferry-boats on the North River ferries having beam engines, one of which was the *Hoboken*, built in 1822, and it is believed the *Pioneer*, built in 1825, also.

We are informed Mr. J. H. Morrison, of New York City, has the only full and correct list of steam vessels built in the United States, with their dimensions of hull and engines, that there is at the present day.—*Marine Journal.*

American Public Buildings.—It is not only jobbery in municipal and State architecture which makes our public buildings inferior as a class to those built by private enterprise. It is not only because the architect of the United States Government is changed from time to time that the works for which that Government is responsible are so often discreditable. The whole system by means of which the Government manages such matters is a bad one—bad not merely in the sense that it is not always well administered, but in the sense that it cannot be so administered as to result in an average of works which would rightly represent the standing of American architecture to-day. Until the system is radically changed—until the architectural business of the United States Government is put upon such a basis that it will tempt the hands of our very best architects, and will permit that many of them shall join in devoting to it a portion of their time—until this good day comes, American *citizens* may feel sure of being as well served (if they wish) as any individuals in the world, but the American *people* must be content with a worse service than any other nation accepts. It must be satisfied to put itself on record as too blind or too indifferent to see and appreciate and secure a quality of work which year by year excites an ever-growing admiration among our foreign visitors. It must submit to perpetuate the sins of a past generation of architects when it might be giving immense assistance to the virtues of the generation which is now at work and of those others which are to follow in its steps, if we may trust our English critics, with still greater freedom of effort and power and skill.—*The Century for March.*

How Not To Do It.—The object of this note is to call attention to an example of faulty construction which will, I think, appeal to those interested in the erection of modern buildings where the use of elevators is so universally demanded.

In a recently completed building in this city can be seen a system of four hydraulic elevators of what is considered approved construction, running in the four corners of a hollow square; the head works being carried by heavy wrought-iron beams extending from one wall to the other.

The sheaves carrying the hoisting ropes of all four elevators are properly placed on top of the beams mentioned, but owing to the fact that the hoisting ropes are all carried through the west wall, it became necessary to place the sheaves carrying the counter balances of the two elevators nearest the west wall, so that they would not interfere with the ropes of the elevators next the east wall.

The method of doing this is the point which I desire to criticise. The shafts of these counter-balance sheaves, instead of being so placed as to be supported by the beams, are hung from the bottom by what are apparently cast-iron bearings, attached to the lower flange of beams by means of two ¾-in. stud bolts. Aside from the uncertainty of obtaining a good thread when it has to be made in place, as these have evidently been done, there is added the uncertainty of the condition of the same, as well as of the bolts, by reason of the combination of "the monkey-wrench and the intelligent workman" who may have made the final adjustment.

In such cases where so many safety appliances are attached to prevent accidents, the faulty construction noted would seem to call for prompt remedy, as the giving way of the suspension boxes or bolts by reason of a sudden jar could hardly fail to cause an alarming accident, if not resulting in loss of life. A little forethought on the part of the designer of the machinery, or of the architect, would have suggested in this case a ready means of overcoming the difficulty encountered.—*Henry G. Morris, before the Engineers' Club of Philadelphia.*

THE RAILROAD AND
ENGINEERING
JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

PUBLISHED MONTHLY AT No. 45 BROADWAY, NEW YORK.

M. N. FORNEY, ... Editor and Proprietor.
FREDERICK HOBART. . . . . Associate Editor.

Entered at the Post Office at New York City as Second-Class Mail Matter.

SUBSCRIPTION RATES.

Subscription, per annum, Postage prepaid $3 00
Subscription, per annum, Foreign Countries 3 50
Single copies 25

Remittances should be made by Express Money-Order, Draft, P. O. Money-Order or Registered Letter.

MR. J. HOWARD BARNARD, 7 Montgomery Avenue, San Francisco, Cal., is the authorized Western Agent for the JOURNAL.

MR. FREDERIC ALGAR, Nos. 11 and 12 Clements Lane, Lombard Street, London, E. C., England, is the authorized European Agent for the JOURNAL.

NEW YORK, MAY, 1888.

THE June number of the RAILROAD AND ENGINEERING JOURNAL will contain the first part of a Study on Steam Hammers, by M. Chomienne, the distinguished French engineer, who has had many years' experience in forge management and construction. This paper will be published by special arrangement with the Author, and is translated from his manuscript for the JOURNAL.

The publication will extend over several months, and the articles will be very fully illustrated, the engravings being prepared from drawings made under M. Chomienne's direction.

WE give this month illustrations and descriptions of two systems of naval coast defense, which are just now attracting much attention here and abroad. The Nordenfelt submarine torpedo boat, of which we have heretofore spoken, has been adopted by several European Governments, and is certainly very formidable within its limited range of action. The Zalinski dynamite gun and cruiser have a much wider range of action and seem to us to be more dangerous weapons, both in attack and defense, than any yet invented. Certainly the dynamite gun has many advantages over any form of submarine torpedo, whether operated from shore or from a boat, and there is little doubt that this will be completely shown by practical tests, whenever they can be made.

THE project for bridging the Hudson River at New York City has so far assumed form that a bill authorizing the building of such a bridge has been introduced in the New York Legislature. A somewhat wide range is given in the matter of location, for the provisions of the bill are that it shall cross the river at some point between 10th and 181st streets, the exact place to be decided on by a commission. It provides for spans not less than 1,300 ft. each, with one pier in the river and a clear height of 130 ft. above high water. The bill does not provide directly for the incorporation of a company, leaving that to the commission which is to be appointed by the Governor.

In the present condition of legislative business at Albany it is doubtful whether such a bill can pass this session. In any event, should a company be organized under its provisions a charter from the State of New Jersey as well as in New York will be required, and also some legislation from Congress.

THE death of General Q. A. Gillmore last month removed from the Army an officer whose services in the field earned him a reputation as a military engineer of the first rank. During the war he was the first officer who realized the capacity and range of rifled cannon, and made use of them in such a way as to secure the full results attainable from what were then the best guns; and in the operations around Charleston and against Fort Pulaski he accomplished several things which had generally been considered impossible up to that time. In a military government he would have attained high rank; in our own he was employed after the war in doing his full share of the varied work which falls upon the Engineer Corps. He could probably have earned wealth and a high position as a civil engineer had he left the Army; but his life had been spent in it, and he preferred to remain there. His ability was generally recognized, however, and few men in the service had a greater reputation outside. Notwithstanding a very busy life, he found time to put many of his experiences on record, and to publish them, and so earned the gratitude of the profession.

DURING the past month there have been an unusual number of deaths of prominent engineers and railroad men, as our obituary column will show. Some of these men belonged mainly to the past, like President Hinckley and Squire Whipple, whose active life was over; others, like Charles Latimer and General Gillmore, were still strong men, and in the ordinary course of events might have looked forward to many years of usefulness. General Gillmore has fortunately left behind him, in his published works, a record of many of his experiences for the instruction of those engineers who may come after him; but Mr. Latimer, than whom few men were more capable of giving practical and thorough instruction in his branch of the profession, has left few records of his experience.

THE new system of payment of car mileage by a mixed mileage and per-diem rate, which has been adopted by several leading roads, has been reviewed and endorsed by a committee of the General Time Convention. This committee reports that the new system has been in operation on 34 lines, including over 23,000 miles of railroad, and that the results so far have been most excellent. The Convention took no action on the report; it was laid over until the next meeting, but there seems to be little doubt that the mixed system will be approved and recommended for general adoption.

OUR Canadian brethren are just at present wrestling with the question of Government regulation of railroads. A Commission was appointed last year to take testimony of this subject and to report to Parliament; this report has just been presented, and is a long and elaborate document.

To speak briefly, the Commission recommends the appointment for the Dominion of Canada of a railroad commission, with certain powers of control and regulation. The bill which has been prepared follows nearly the general outline of our own Interstate Commerce Law. The report is not final and is subject to revision by the Government, which may adopt the proposed bill complete or take up only a part of it.

One important point of difference between the Canadian railroads and our own is that the Government of Canada owns and operates directly the Intercolonial and two or three other lines of considerable importance, and that a large number of the roads have been built by the aid of subsidies by the Government ; a condition of things which does not exist on this side of the line.

THE *Railway Age* publishes statistics collected by it in relation to track laying during the current year. From its figures it appears that from January 1 to March 31 there were laid in the United States 1,096 miles of track, a few miles more than during the corresponding time last year. As might be expected, the larger part of this work was in the Southern States, the weather in the North and Northwest generally preventing new track work during the winter months. The conclusion drawn by the *Age* is that the mileage of new railroads to be built this year will be probably much larger than has generally been expected, and that it may possibly almost reach last year's figures.

This conclusion does not seem to be altogether warranted by the facts. After a year of extensive construction such as 1887 was, there are always a great many lines left in an unfinished condition, and the track on these is very apt to be laid as early as possible in the following year. Much of this work has already been done, and, with the exception of two or three in the Southwest, there are now no long lines in progress upon which much work is likely to be done this season.

As we have already said, it is true that there are an enormous number of new projects, and that many new companies have been and are continually being organized. This amounts to very little, however, and the greater part of these companies are simply the after-crop of a period of extravagant construction, the prospects being that very few of them will ever build railroads anywhere except on paper.

It is also an incentive to construction that rails and other material are much cheaper than they have been for some time past. It does not follow, however, that new construction will be stimulated thereby, the fact being that while material is cheaper, it is not now an easy matter to get money for new projects.

We do not mean to say that there will not be a good many miles of railroad built this year, but the present prospect is that there will not be nearly as many as last year ; probably less than the 8,000 miles which the *Age* gives as the minimum estimate. New companies, as we have said, find it very difficult to get money, and some of the old companies are reaching a point where their credit will not stand further loans at moderate interest. The fact is, as every one who has studied the matter knows, that the building of competing lines in new territory was entirely overdone last year. While many branch lines were constructed which are sure in course of time to build up a prosperous country and to make themselves well-paying feeders, could they have the field to themselves, there has been too much work done in building two or three roads in districts which are not and will not be able to properly support one road for the next five or ten years to come.

These lines must be operated, and they must cost something to work. The expense of working them has already been seriously felt by several of the companies which have been the greatest sinners in this direction, as their reports begin to show. The indications are that this kind of work will be more limited in amount this year than last, and this will not be altogether a misfortune.

IN Austria-Hungary, as in the United States, railroad building was active last year. There were added to the railroad lines of that country during the year 1,281 kilometers (796 miles) of new road, being an increase of about 5½ per cent. This is the largest addition made since 1873, when 1,703 kilometers were built, though 1884 came very near it, with 1,250 kilometers. The greatest mileage ever built in one year was 2,129 kilometers, in 1872. After 1873 the new construction fell off sharply to 504 kilometers in 1874, and then gradually declined to 61 in 1880. In the next year building was resumed and increased rapidly until 1884, but there was a great falling off in the two succeeding years, 1885 showing only 495 and 1886 only 672 kilometers. The fluctuations of new railroad building have thus followed pretty closely those of our own country.

Of the new line built last year just half—640 kilometers—were local and branch roads (vicinalbahnen), belonging to the Imperial State railroad system. About 30 per cent. of the total belonged to the State lines also, only 258 kilometers, or 20 per cent., having been built by the private railroad companies.

Hungary had the greater share of the new lines, 750 kilometers, against 531 in Austria. This has been the case for several years past. Austrian writers call this the era of local development in the railroad system, and note that the State system is increasing much faster than the private lines.

At the close of 1887 there were in the Empire 23,926 kilometers (14,868 miles) of railroad, of which 14,187 kilometers were in Austria and 9,739 in Hungary. There is evidently more room for development in the latter country, which has a greater area, but a less dense population, than the former.

PROBABLY there is no country in the world in which the question of irrigation has been more carefully studied than in India, and there is none in which it has been carried out on a more extensive scale. An instance of what has been done in this direction is found in a recent official report on the system of irrigation canals in the Punjab. At the close of 1887 there were in that province a total length of 3,770 miles of main canal and 5,675 miles of auxiliary distributing channels, which served to irrigate a total of 1,950,640 acres of land. The crops taken from this area were last year very nearly equal in value to the entire cost of the system. Some of the main canals are of great length, the Muzuffargarrh Canal having 693 miles of water-way, the Lower Sutlej 674, the Indus Canal 651, and the Sirhind Canal 536 miles, while there are three others over 200 miles in length. The system has been so successful that it is to be considerably extended ; 106 miles of main canal and about 1,000 miles of distributing channels are now under construction, while surveys have been made for other lines.

As an investment these canals have been satisfactory to the Government as well as to the landowners. The net return to the Government last year was equal to 3½ per cent. on their cost, and more is expected when the system is fully completed. The increase in production is not stated, but it has been very large.

The Punjab, it is stated, presents an admirable field for irrigation. The land is of good quality, but production has been limited by a scanty and uncertain rainfall. The supply of water, however, is abundant, as the country is intersected by numerous rivers, which are fed by the mountain streams and snows of the Himalayas. There is also a population large enough to cultivate all the land, when there is a certainty of water-supply and consequent good crops.

Indirectly the extension of these works is of interest to American producers, as nearly half the irrigated area was last year planted in wheat; and Indian wheat is fast becoming a formidable competitor of American grain in the English market.

EVER since the English conquered and annexed Burmah, they have been trying to open a railroad route from the upper part of that country into India. The object is not only to strengthen their military position, but also, by an extension of the line eastward, to secure the trade with China, which is now carried on by caravan, and which is already considerable, but which could be largely increased by a railroad. Recent explorations have shown the existence of several low passes in the Patkoï Mountains —heretofore considered impassable—and the road will probably be built.

THE Russian engineers on the new line in Central Asia have been much troubled with sand-drifts blocking the line. From Merv to the crossing of the Amu-Daria the line runs across a plateau, which is peculiarly exposed to high winds, and where the soil is light and sandy, with very little vegetation. After many experiments they have settled on the use of a native bush called *saksaoul*, which grows rapidly, sometimes to a height of 15 or 20 ft., and sends its roots down very deep into the sand. A plantation of this bush along the line not only covers and consolidates the soil on which it grows, but also interposes an effectual barrier to the drifting of sand from the bare plains beyond. The *saksaoul* bushes are being planted all along the line, and strict orders have been issued against cutting them down either in the new plantations or in those already existing. Other methods have been tried, but this seems the most promising.

Much trouble from the same cause was experienced on the Southern Pacific line across the Yuma Desert in Southern California. The sand-drifts were much worse to handle than snow-drifts, for the reason that sand packs down hard where it drifts and cannot be handled by a snow-plow, the shovel being the only resort. On the Southern Pacific the only effectual preventive has been to encourage the growth of vegetation wherever possible, and the Russians seem to have reached the same conclusion.

A NEW one-rail railroad has recently been completed between Listowell and Ballybunion in Ireland. It is 10 miles long and is on the Lartigue system, consisting of a line carried on posts and having a cross section like a letter A. The weight is carried on the top rail, the cars, which are shaped like a saddle, fitting over the top of the A, having wheels or rollers below merely to steady them and keep them in place. The new line is intended to serve a light local traffic, and carries both passengers and freight. It follows closely the line of a highway road, and its cost was quite small. It is reported to be working very successfully thus far.

AUTOMATIC CAR COUPLERS.

THE announcement and an engraving of the long-expected "contour lines" for the Master Car-Builders' standard type of automatic coupler will be found on another page. As this is the consummation of lengthy investigations and somewhat warmly contested disputes over an important question, a statement of what has been done will probably interest many of our readers. The subject of car couplers has always attracted a good deal of attention in the Master Car-Builders' Association, and has been up for discussion annually for so long that the "memory of man runneth not to the contrary."

At the convention held in Saratoga in 1884 a resolution was adopted to the effect that it was "the sense of the convention that the best coupler mechanically is one which performs the coupling along a vertical plane." This resolution was unanimously adopted, although it was doubtful whether, at the time, most of the members who voted for it understood its significance. The description of the class of couplers referred to as those "which perform the coupling along vertical planes," was not very correct nor accurately descriptive, as it would be hard to designate a plane, either actual or imaginary, along which the coupling is performed. If the class of couplers referred to had been described as those which perform the coupling along vertical *surfaces*, it would have been more correct, although that would still have been a little vague. The class of couplers referred to couple by means of hooks which engage with each other and whose surfaces of contact are vertical. The most notable of these couplers are the Miller and Janney, both used extensively on passenger cars, and the Janney to a considerable extent on freight cars.

Owing to the fact that the resolution adopted at Saratoga was not understood at the time of its adoption by more than a very few of those who voted for it, it had a very slight influence on the action of the members of the Master Car-Builders' Association or the railroad companies of the country. At the meeting held the next year at Old Point Comfort a motion was adopted "to refer to the Executive Committee the subject of automatic freight-car couplers, with the power to arrange for and conduct a public trial at some central point, to employ one or more experts, and to solicit the co-operation of the railroad companies in making trials and in furnishing the funds for conducting the same."

In accordance with this resolution, a public trial of couplers was made at Buffalo, N. Y., in September, 1885, and twelve different kinds of couplers were recommended "for further trial in actual service."

Most of those recommended were put into actual service during the following year, and much valuable experience was gained from their use.

Last year, at the convention held in Minneapolis, the Executive Committee made a lengthy and final report on automatic couplers, and concluded with the recommendation:

"That this Association recommend as a standard form of coupling the Janney type of coupler; that the Association procure one of the present make of Janney couplers, selection being made by a committee appointed for that purpose, and then all other forms of couplers that will automatically couple to and with this coupler under all conditions of service are to be considered as within the Janney type, and conforming to the standard of this Association."

This recommendation was submitted to letter-ballot, and was approved by a vote of more than two-thirds of the ballots cast. A sub-committee was then appointed to "procure one of the present make of Janney couplers." The committee, after careful investigation, recommended the form of contour lines of the Janney coupler, represented by the engraving on another page, as the standard of the Association.

During the investigations of the sub-committee it was found that these contour lines were the subject of a patent granted to Mr. Janney in 1879. With very great liberality the company which controls this patent agreed to waive their rights to the contour lines as described in the patent referred to—as is detailed in a circular issued by order of the Executive Committee of the Master Car-Builders' Association, and which is also published on another page.

It will be seen that this action of the Association—which is the culmination of the investigations carried on for a number of years past—is very important. It establishes a distinct class of couplers as a standard, and it designates the form of the coupling faces so as to insure interchangeability, or, rather, intercoupleability—to coin a word—of different kinds of couplers of the vertical surface type. The field is left open for inventors to improve this type of couplers, but confines their improvements to forms which will couple with each other. It will also be an immense relief to railroad managers, car-builders, and editors of technical papers to have an extinguisher for the great army of cranks who have been devoting their time and ingenuity to the invention of couplers of all degrees of impracticability. To these and to all other inventors it may now be said that the action of the Master Car-Builders' Association, so far as it has any influence, excludes all couplers which do not "perform the coupling along vertical surfaces" whose contour lines are of the form prescribed by the Association.

Doubtless there is still room for improvement of this type of coupler, and inventors now have the advantage that the direction in which they must work is indicated to them, and also that if they can make any real improvement in this class of couplers they may be quite sure that their inventions will receive consideration. Couplers of the Janney, or, as it has been rechristened, the M.C.B. type, are sure to be put into service in large numbers. Naturally railroad companies will want to get the best form of that type. By the action of the Master Car-Builders' Association car couplers, instead of being one of the most hopeless subjects on which invention can be exercised to advantage to the inventor, now promise a rich reward to whoever can make a real improvement in the construction of the type which has been adopted.

NEW PUBLICATIONS.

MECHANICAL DRAWING: BY LINUS FAUNCE. Boston; W. J. Schofield, Printer, 105 Summer Street.

This is a small book originally prepared for the use of the students of the Massachusetts Institute of Technology and now offered to the public. It consists of chapters on Instruments and their Uses; Geometrical Problems; Inking and Tinting; Projections and Notation; Shadows; Isometrical Drawing; Oblique Projections; Working Drawings and Examples.

The directions are very clearly given, and the selection of geometrical problems is excellent. It is a very good introduction to the study of mechanical drawing, but its value would be very much increased if more space was devoted to the practical application of the principles explained. Only six pages and a few rather meager and conventional plates have been devoted to this portion of he subject.

A TEXT-BOOK ON ROOFS AND BRIDGES. PART I: STRESSES IN SIMPLE TRUSSES: BY MANSFIELD MERRIMAN, PROFESSOR OF CIVIL ENGINEERING IN THE LEHIGH UNIVERSITY. New York; John Wiley & Sons (pp. 118; price, $2.50).

It is stated in the preface that this work constitutes a part of the course in civil engineering in Lehigh University. It covers the ordinary ground of line structures for bridges and roofs, and treats of the common forms of these structures now in use. The articles are short, each containing numerical examples involving the principles discussed in the previous pages. It is a very good work for class-room drill. The more difficult problems for the student, such as Double Systems, Lateral Bracing and Economic Depths, are brief. The Author has not exhibited his well-known ability for analyzing difficult problems, but has kept himself well down to the level of the undergraduate student. The details of those structures, the most difficult part of the general problem of designs, are not considered in this work, but, as stated by the Author, will be treated later in the course.

ZWICKER'S INSTRUCTOR FOR STATIONARY AND STEAM ENGINEERS' LICENSE: BY PHILIP HENRY ZWICKER, PRACTICAL ENGINEER AND MACHINIST. St. Louis, Mo.; published by the Author.

This is a little book by an author whose chief qualification for the work he has undertaken is that he has had practical experience. From the book it would be safe to draw the inference that he has had more experience as a practical engineer than he has had in authorship. The book is extremely crude, the directions often far from clear, and rules of grammar are often disregarded. Thus, to the question, "What is an injector or inspirator?" we have the answer: "They *are* a device to answer for a pump in feeding a boiler." "What *is* the best gauge-cocks?" is another error that a proof-reader should have corrected if the Author did not. Caulking is spelled "corking," and to the question "Which is the hottest, steam or water?" we have the answer: "They are the same, only water will retain the heat longer, as water is a body and steam a vapor."

The book contains information of different kinds which,

perhaps, may be valuable to some practical men, but it is of the most elementary sort.

American Street Railways: Their Construction, Equipment, and Maintenance: by Augustine W. Wright, Consulting Engineer. Chicago and New York; Rand, McNally & Co.

Mr. Wright, who has had many years' experience in the construction and management of street railroads, has written and published the first book which embodies the results of American practice on this class of roads. He has done engineers and others interested in such work a service, for the only sources of information heretofore have been scattered articles and reports, which were accessible only with difficulty, if at all.

The book includes chapters on Track Construction; Paving; Track Cleaning; Equipment; Buildings, including stables, car-houses, etc.; and Management. An appendix contains calculations, based on experience, on the amount of horse-power used in propelling street cars.

Mr. Wright's book refers entirely to horse railroads, and he does not treat of cable roads, electric motors, or other devices for superseding horse-power. It is practical and is based on experience, and will doubtless be of much service to those for whom it is written.

How large this interest is may be appreciated when it is stated that there are in the United States nearly 6,000 miles of street railroad, on which some 22,000 cars and over 100,000 horses are in service.

Notes on the Compressive Resistance of Free-stone, Brick Piers, Hydraulic Cements, Mortars, and Concretes: by Q. A. Gillmore, Ph.D., Colonel Corps of Engineers, Brevet Major-General, U.S.A. New York; John Wiley & Sons, 15 Astor Place (price, $3.50).

This latest work of General Gillmore appears almost simultaneously with the announcement of his death. Like all his published works in this direction, it derives great value from his known care and accuracy in experimenting and from his quickness and ability in generalizing and deriving results. The present book is chiefly devoted to a number of tests of building material and cements, made with the assistance of the great testing machine built at Watertown Arsenal for the Government by Mr. A. H. Emery some years ago. The opening chapters are occupied by some historical accounts of the investigations previously made for ascertaining the nature and strength of building stones, and by a careful description of the methods of making tests and of preparing the specimens.

The special series described included tests of Haverstraw free-stone and several different kinds of cements and mortars. A very interesting chapter is devoted to tests of brick piers, with the phenomena attending their breakage; those described in the present book were a continuation of a series made at the Watertown Arsenal some time previously. The results of all the tests are very fully and completely tabulated in an appendix, and are illustrated by strain-sheets and diagrams. With regard to the much-vexed question of cement tests the work is very complete, and adds some interesting facts to the knowledge already acquired on this subject. The results of these tests are summed up as follows:

"1. Mortars are generally not as strong as the concretes made with those mortars.

"2. The sets of mortars and concretes richest in cement proved stronger than the others.

"3. The smallest (4-in.) cubes in each of the four sets were decidedly the strongest of the lot.

"4. There is no apparent law of increase or decrease of strength per square inch of bed-area as the size of cubes increases."

In conclusion the Author suggests a further series of tests to ascertain not only the compressive strength, but the elasticity and other qualities of the best-known cements; and also that parallel tests should be carried on by repetition of loads below the crushing load in order to ascertain the existence of a law by which it may be possible to discover the maximum load which can alternately be put on and taken off without injury. He also suggests a trial of the effect of weights falling from certain heights upon material whose resistance both under steady pressure and also under repeated loads is known.

Photography Applied to Surveying: by Lieutenant Henry A. Reed, U.S.A., Assistant Professor of Drawing, U. S. Military Academy, West Point, N. Y. New York; published by John Wiley & Sons, 15 Astor Place.

This is a clear, explicit, and interesting description and explanation of the application of Photography to Plane and Topographical Surveying.

The subject is one to which very little attention has been paid in this country, as the Author remarks in his preface, and its advantages, both as to rapidity and accuracy of work, are very little understood.

The Introduction contains an historical sketch, showing the improvements and advances which have been made from time to time in the instruments and methods used, with also a brief but clear statement of the general principles upon which is based the construction of plans from perspectives or photographs, being the reverse of the ordinary methods of making perspectives from plans with the elevations.

The Methods of Plane Perspectives follow, with a full description of instruments, materials, and manner of work. In this method the ordinary photographic camera can be used, one or two slight and inexpensive additions being made to facilitate the work, but these are not an absolute necessity. The methods both in the field and office are so clearly explained that only a very slight knowledge of surveying or photography is necessary in order to conduct the work.

The more advanced methods are then discussed, including cylindric perspectives, radial perspectives, and the camera without a lens. In these methods specially constructed instruments are used, and the results obtained are in every way more satisfactory.

A full description of the various instruments, with the method of use in the field and plotting in the office from the photographs, is given. There is an interesting and instructive chapter on Telescopic and Balloon Photography, showing the great advantages it possesses for military reconnoissance, etc. The book closes with a detailed account of the various applications of photographic surveying and some of its advantages. Certainly its advantages are many, and much time and money would be saved by its more general adoption.

It is of almost universal application, from the survey of the ordinary farm up to the finest and most detailed topographical map. As the Author says, "In no other way can such thoroughness of detail be obtained, and in the end we have not only an accurate topographical map, but also photographs of the section surveyed which present to the eye natural views of this section.

"These, taken in connection with the map, often make possible the location of engineering works of any description without the necessity of an actual examination of the ground."

Lieutenant Reed treats the entire subject in a most clear and concise manner, and the book is one which will well repay a careful study by any persons interested in the subject, either as professionals or amateurs.

BOOKS RECEIVED.

HARPER'S WEEKLY for April 21 contains a large double-page plate showing all the new vessels now under construction for the United States Navy. The plate, of course, gives only an outside view, showing the general appearance the ships will have when completed, and not illustrating further the special features of their construction. It includes 16 vessels, varying in size from the great armored cruiser *Maine* to the little torpedo boat not much larger than a first-class launch. It is of interest as showing the wide departure of the new from the old Navy.

In the POPULAR SCIENCE MONTHLY for May there will be published an article by Mr. Arnold Burges Johnson on Sound Signals at Sea. In this article will be described a number of new and ingenious devices for communication between ships and to give warning of the nearness of and direction of dangerous objects.

In SCRIBNER'S MAGAZINE for June, it is announced, will be begun the publication of the series of illustrated articles on Railroads of which some reference has heretofore been made. The first article will be on the Building of a Railroad, and will be by Thomas Curtis Clarke, the well-known engineer. He will describe briefly the process of locating and building a railroad from the first preliminary reconnoissance to the final laying of the track. Other articles of the series so far announced are: Engineering Feats, by John Bogart; Locomotives and Cars, by M. N. Forney; Passenger Travel, by Horace Porter; Railroad Employés' Life, by B. B. Adams.

ETUDE GENERALE SUR LES MARTEAUX-PILONS: PAR C. CHOMIENNE, INGENIEUR DES FORGES DE L. ARBEL, RIVE-DE-GIER, LOIRE, FRANCE. Paris; Imprimerie Chaix. This is the paper which this year received the first prize of the Society of Graduates of the National Schools of Art and Trades at Paris.

PROCEEDINGS OF THE UNITED STATES NAVAL INSTITUTE: VOLUME XIV. Annapolis, Md.; published by the Institute.

PROCEEDINGS OF THE MICHIGAN ENGINEERING SOCIETY AT ITS SEVENTH AND EIGHTH ANNUAL CONVENTIONS (1886 and 1887). Kalamazoo, Mich.; published for the Society.

OCCASIONAL PAPERS OF THE INSTITUTION OF CIVIL ENGINEERS. London, England; published by the Institution. The present issue includes the following papers: Discharge of Rivers, by Professor A. R. Harlacher and H. Richter; Electrical Tramways, by Edward Hopkinson; Hydraulic Appliances at the Forth Bridge Works, by Ernest William Moir; Engineering Laboratories of the Massachusetts Institute of Technology, by Professor Gaetano Lanza; Locomotives and Rolling Stock of the Bengal & Northwestern Railway; the Sulina Mouth of the Danube, by Charles Henry Leopold Kühl; the Government Testing Works at Malines, Belgium, by E. J. Roussel.

TRANSACTIONS OF THE ARKANSAS SOCIETY OF ENGINEERS, ARCHITECTS, AND SURVEYORS: VOLUME I, NOVEMBER, 1887. Little Rock, Ark.; published by the Society.

JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, VOLUME II, NUMBER 3. Published by the Board of Editors; Secretary's Office, New Bedford, Mass.

FIFTH ANNUAL REPORT OF THE BOARD OF RAILROAD COMMISSIONERS OF THE STATE OF KANSAS, FOR THE YEAR 1887: JAMES HUMPHREY, ALMERIN GILLETTE, AND A. R. GREENE, COMMISSIONERS. Topeka, Kan.; State Printer.

REVISTA DE OBRAS PUBLICAS E MINAS: PUBLICACAO MENSAL DA ASSOCIACAO DOS ENGENHEIROS CIVIS PORTUGUEZES. Lisbon, Portugal; National Printing House.

A TREATISE ON ARTIFICIAL REFRIGERATION. New York; issued by the Consolidated Refrigerating Company. This is a well-illustrated description of the system of artificial refrigeration adopted by the company named above, and now in practical operation.

TRUE INWARDNESS: BY AN HONEST MAN. Newton, Mass.; Sterling Elliott. This is not only an admirable specimen of typographic and artistic work, but it is also the most original and witty specimen of a catalogue we have ever seen. Works of that kind are usually very dry reading, but this is one which will not only take the eye of the reader, but will command his attention. It is useless to attempt a description of its contents; the book must be seen to be appreciated.

ILLUSTRATED CATALOGUE OF THE BROWN & SHARPE MANUFACTURING COMPANY. Providence, R. I.; issued by the Company. This catalogue is issued in a neat and compact form, the size ($5\frac{1}{2}$ by $3\frac{1}{4}$ in.) being such that it can be carried in the pocket and will take but little room on a desk. In its 175 pages is a full list of the wide range of machine tools and of the numerous gauges and other tools for accurate measurement manufactured by the Company. A great convenience which should be found in all catalogues of this kind, but is often omitted, is a full index of the contents.

LANSING IRON & ENGINE WORKS: CATALOGUE OF MILL SUPPLIES. Lansing, Mich.; issued by the Company.

SOMETHING ABOUT CULVERT PIPE: ITS MATERIAL, ITS MANUFACTURE, ITS USES. St. Louis; Blackmer & Post, Equitable Building.

KEYSTONE STEAM PUMP WORKS: CATALOGUE. Pittsburgh, Pa.; Epping, Carpenter & Company, Limited.

THE KORTING GAS ENGINE: CATALOGUE. New York; issued by the Korting Gas Engine Company, Limited.

CORRUGATED AND OTHER SHEET METAL BUILDING MATERIAL: CATALOGUE. Issued by the Cincinnati Corrugating Company, Cincinnati, O.

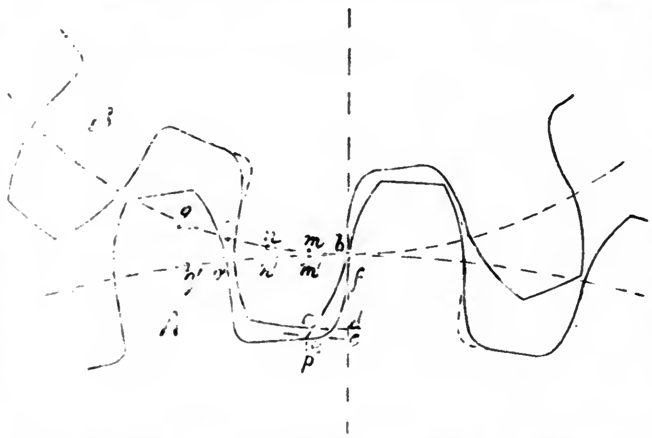
Contributions.

Clearance Curves for Gear-Teeth.

To the Editor of the Railroad and Engineering Journal:

In the discussions of the shapes of gear-teeth given by writers on mechanics, it will be found that no definite instructions are given relative to the curves connecting the flanks of the teeth with the rim of the wheel or the clearance curves. In heavy gearing, transmitting large powers, this may be an important point, for the shapes of these curves may modify considerably the strength of the teeth.

The figure herewith illustrates the so-called radial-flank epicycloidal tooth. The usual method of connecting the



flanks to the rim is by a fillet whose radius is chosen small enough to insure ample clearance for the points of the teeth of the mate gear, as shown by the teeth *A* and *B*.

A better method, to which attention is called, is the following: Having determined the proper curve *a b* for the point of the tooth, mark a point *p* on this curve, at a distance beyond the extreme outside of the tooth equal to the radial clearance *c d* of the gears. Then find the path *e f* that this point would describe on the other gear when the teeth are in action. This path may be easily determined in the following way: Lay off a number of equal distances, *m n o q, m' n' o' q'*, on the pitch circles from their intersection, *b*. With the distances *mq, nq, oq*, etc., as radii, describe arcs from the points *m', n', o'*, etc. The curve tangent to all these arcs will be the required clearance curve. It will be seen that this is a more rational way than has been usual of determining the shape of this part of a gear-tooth, and it will generally be found that this curve increases the strength of the tooth.

This method may be applied to any of the various forms of teeth in use. It was devised by the writer and applied to some very large gears in about the year 1871, but so far as known to him, has not been published before, although it has been used a good deal by others.

A. K. MANSFIELD.

No. 280 Broadway, New York.

STRESS IN CONTINUOUS FRAMED GIRDERS.

BY J. HIROI.

IT is a well-known fact among engineers that the discussion on stresses in continuous girders has been a subject, especially in America, of comparatively little interest to practical men, and it is almost such, that were it not for the necessity of constructing drawbridges and for some daring works like those of the Kentucky River, Minnehaha, and Lachine bridges calling the attention of the engineering public, few would even take any notice of the subject. Some look upon those long series of formulæ which characterize the calculation of stresses in continuous girders with a sort of suspicion, while eager beginners try to catch the first opportunity of making use of the Clapeyronian formula, calculating reactions to a single pound, more often forgetting the fact that the formula as ordinarily given is only applicable under very restricted conditions —viz.:

1. When the modulus of elasticity is a constant throughout the girder.
2. When the moment of inertia of a section of the girder is constant everywhere.
3. When the supports are of such height that the neutral axis of the girder is undeformed when the girder is weightless.
4. When the deflection of the beam is not very great.
5. When the girder has such a form that $d\,s = d\,x$, s being length along the neutral axis of the girder and x the horizontal.
6. When there is no deflection due to the deformation of the web.

How far all these conditions are fulfilled in ordinary cases every one can easily judge for himself.

One reason why the formula of continuous girders is looked upon with suspicion may in some cases be that most people—instead of stopping to think that a girder lying over more than two supports is nothing but a similar girder whose deflections, due to loading, are worked back so that at the points of support it occupies the original position of unstrained girder—merely look at the formula, whose derivation is not, of course, so simple as the mere principle of a lever.

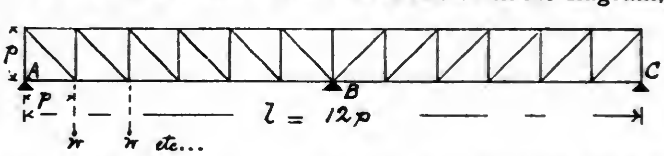
The first three conditions mentioned need not be fulfilled in the theorem of three moments in an extended shape. Weyrauch has given a very complete solution for such cases in his "Theorie der Einfachen und Continuirichen Träger."

The fourth and fifth conditions are generally fulfilled in ordinary bridges.

The sixth, which is usually neglected, will be here taken up, to show what difference this neglect gives to the calculated stresses in continuous framed girders. A straight framed girder over three level points of support will be taken, the girder being merely supported at the ends.

To make the calculation plainer, instead of using the Clapeyronian formula, the girder, as already said, will be considered as a simple girder whose deflection at the middle point is restored to its unstrained condition. That this involves the same principle as the Clapeyronian formula—viz., the equation of the elastic line, is evident to any one who has studied the subject.

Let the truss have its members as shown in the diagram,



and let each panel point be loaded with an equal weight *W*. Further, let the girder have constant cross-section throughout.

Then, on the supposition that the support B does not exist, we obtain the amount of deflection at the point due to the deformation of chords by the ordinary formula of deflection :

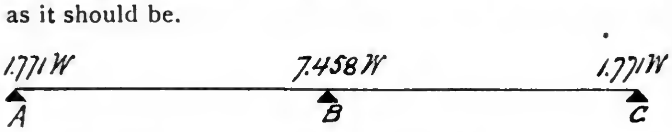
$$\delta = \frac{1}{24\, I\, E} \sum^{\frac{2}{3}} W a\,(3\,l^2 - 4\,a^2) = \frac{6444\; W p^3}{24\, I\, E}.$$

Now, in order to undo this deflection, or, in other words, to put in at B an immovable support level with end ones, an upward reaction must be exerted at B, which can deflect the girder at that point by the same amount as δ. Let P be such reaction. Then we have at once from the formula of deflection, with load at the middle :

$$\frac{P\, l^3}{48\, E\, I} = \delta = \frac{6444\; W p^3}{24\, I\, E},$$

from which $P = 7.458\; W$.

Consequently we obtain the following reactions, exactly the same as obtained from the theorem of three moments, as it should be.



This gives the moment at B to be equal to

$$1.771\; W \times 6\,p - W p\,(5 + 4 + 3 + 2 + 1) = - 4.374\; W p.$$

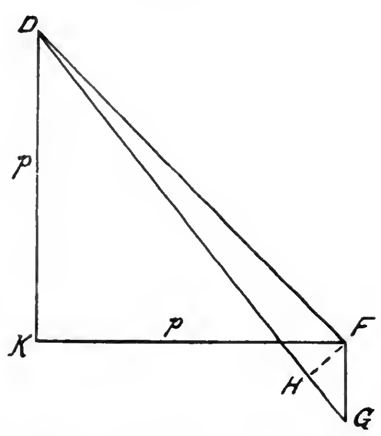
We will now see what difference will be brought about in reactions and moment when the deflections due to the deformation of web-members are taken into consideration. For simplicity's sake we will assume that the chord and each web-member have a constant cross-section C.

The deflection due to weights W, once more under the supposition that the girder is supported at A and C only, is :

from verticals : $\sum \frac{p\, s}{E\, C}$, in which s represents the stress acting in several verticals, and E = mod. of elasticity as before.

$$\sum \frac{p\, s}{E\, C} = \frac{p\, W}{E\, C}(.5 + 1.5 + 2.5 + 3.5 + 4.5 + 5.5) = \frac{18\; W p}{E\, C}$$

from diagonals, since the original length $D\,F$ is equal to $\sqrt{2\,p^2}$ its elongation is $\frac{s^1 \sqrt{2\,p^2}}{E\, c}$, when s^1 is the stress.



Since the angle $F\,D\,G$ is very small under all circumstances, we can assume that $\frac{s^1 \sqrt{2\,p^2}}{E\, C} = H\,G : D\,K :: F\,G : D\,F$, from which $F\,G = \frac{s^1 \sqrt{2\,p^2}}{E\, c} \times \sqrt{2\,p^2} \times \frac{1}{p} = \frac{2\, s^1\, p}{E\, C}$,

and hence the deflection $= \sum \frac{2\, s^1\, p}{E\, C}$

$$\sum \frac{2\, s^1\, p}{E\, C} = \frac{2\, p\, W}{E\, C}(.5 + 1.5 + 2.5 + 3.5 + 4.5 + 5.5)\ \text{Sec. } 45^\circ$$
$$= \frac{50.9\; W p}{E\, C}.$$

Consequently the total supposed deflection at the point B due to the deformation of the web is

$$\frac{18\; W p}{E\, C} + \frac{50.9\; W p}{E\, C} = \frac{68.9\; W p}{E\, C}.$$

This, added to the deflection due to the deformation of chords, as already found, gives the total of

$$\frac{68.9\; W p}{E\, C} + \frac{6444\; W p^3}{24\, I\, E}.$$

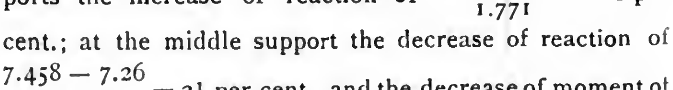
Now it is merely necessary to find the amount of upward force, which we will call P^1, which, acting at B, deform the girder, chords, and web both, to produce the upward deflection equal to this amount. From what has already been said in regard to the downward deflection, it is clear that

$$\frac{68.9\; W p}{E\, C} + \frac{6444\; W p^3}{24\; I\, E} = \frac{P^1\, l^3}{48\, I\, E} + \frac{P^1}{2} \cdot \frac{6\,p}{C\,E} + \frac{6\, P^1\, p \cdot \text{Sec. } 45^\circ}{C\,E},$$

in the second member of which the first term is the amount of deflection due to the deformation of chords by P^1, and the second term that of the verticals ; and the last, that of the diagonals both due to the shearing $\frac{P^1}{2}$. From the assumption we have made $I = \frac{C\, p^2}{2}$; consequently we obtain at once from the above equation

$$P^1 = 7.26\; W.$$

Thus we have new reactions as follows :



The bending moment at B now becomes

$$1.87\; W \times 6\,p - W p\,(5 + 4 + 3 + 2 + 1) = - 3.78\; W p.$$

These figures show that by taking the deflection due to the deformation of web-members we obtain at end supports the increase of reaction of $\frac{1.87 - 1.771}{1.771} = 6$ per cent.; at the middle support the decrease of reaction of $\frac{7.458 - 7.26}{7.458} = 2\frac{1}{2}$ per cent., and the decrease of moment of $\frac{4.374 - 3.78}{4.374} = 13\frac{1}{2}$ per cent. from what the ordinary calculation gives.

These are true only under the assumptions we have made and for the girder we have taken as an example. Every other case will have its own variations of stresses corrected for the deformation of web-members ; and the above merely indicates the simple method of procedure for calculation. In plate-girders the deflection contributed by the web is almost inconsiderable, and the ordinary formula applies with correctness sufficient for all practical purposes.

THE PRINCIPLES OF RAILROAD LOCATION.

By Professor C. D. Jameson.

(*Continued from page* 159.)

CHAPTER XVIII.

OFFICE WORK.

In plotting the notes, both in the field and in the office, when the maps are to be finished up, the following rules, taken, to a great extent, from the *Instructions* of the Chief Engineer of the Atchison, Topeka & Santa Fé Railroad, may be followed with advantage :

All lines should be clear, uniform, and distinct, avoiding hair lines.

The only ink used should be well-ground India ink, except where time may be more of an object than finished plans.

When prepared ink is to be used, the photo-black drawing ink of Keuffel & Esser is the best.

All figures and notes on the map should invariably be in the same black ink.

The line of the survey should be drawn in some chemically opaque red, such as would result from the admixture of good cake carmine and cadmium. The P. Cs. and P. Ts. should be shown, and also the length of the radii of the curves put on in figures.

Colored ink should never be used, especially upon tracings.

Gamboge should never be used either alone or in any combination.

All tracing should be done on the rough or unglazed side of the linen.

On every map or drawing, as near the left-land lower corner as possible, should be written distinctly the title, scale, and date of execution.

When maps are to be highly finished and are for exhibition before a board of directors or other men who are not engineers, it is admissible to use an elaborate finish, but in all cases where they are for the use of engineers, and are not for show, the lettering, etc., should be as plain and distinct as possible, and without any unnecessary work. The best form of lettering for notes, etc., is what is called "stump" writing, and it will well repay any engineer to practise this style of writing until he can do it with speed and neatness. For titles, what is called "round" writing is by far the best, as it is very neat, and with a little practice can be done with great speed.

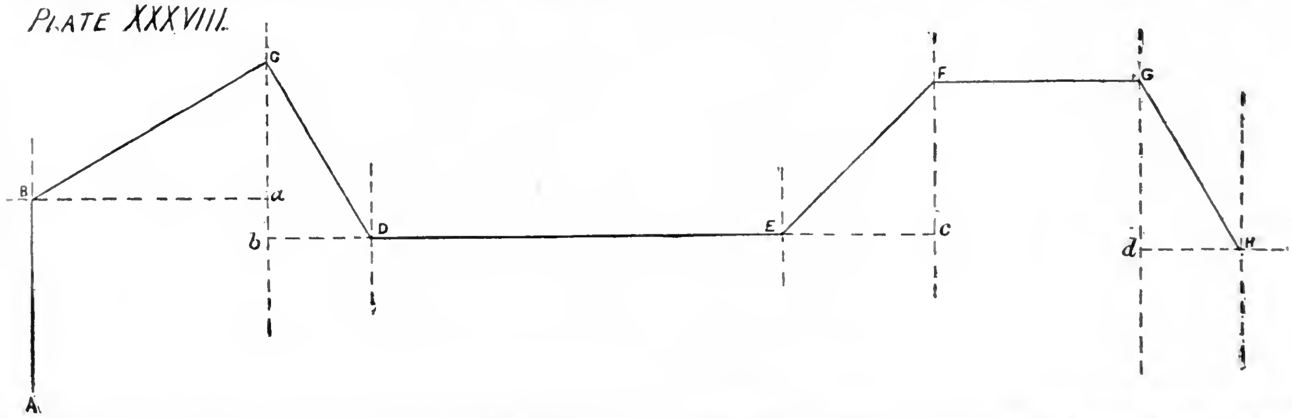
The small metal protractors which come with instruments are absolutely worthless. The only protractors which should be used in the field are paper protractors, and in the office either paper protractors or large and expensive metal ones with micrometer adjustments.

On contour maps the contour lines should be put in in some color other than black. Different shades of brown are the best. Every fifth line should be noticeably heavier than the others, and should have its height distinctly written upon it in a sufficient number of places to make it always easy to find. Unless contour maps are made in this way they are worse than worthless, and all the time spent in the field collecting the data has been wasted. Plates XXIX and XXX are good illustrations of contour maps, and are copies of work actually done in the field.

When a long, broken line is to be plotted the most accurate manner of doing the work is by means of "Latitudes and Departures." Suppose we have the broken line *A B C D*, etc. (Plate XXXVIII), the different straight lines of which it is composed meeting at the angles noted on the plate. We will suppose *A B* is a north-and-south line, and we draw it vertically on the paper and scale off its proper length.

We have the angle *C B a* and the length of the line *B C*. We then find the distance *B a*, which is the cosine of the angle *C B a*, and is called the departure of the point *C*. Lay off this distance on a horizontal line through *B*. Then find the distance *C a*, which is called the latitude of the point *C*, and is also the sine of the angle *C B a*, and lay it off on a vertical line drawn through *a* ; this gives the exact location of the point *C* ; then connect *C* and *B*.

PLATE XXXVIII.



We then proceed in the same manner with the point *D E F*, etc., every point being located by means of one vertical and one horizontal line.

In cases where the line has been run by means of the needle, so that we have the magnetic bearings of each line, they are all referred to a north-and-south line, and the latitudes and departures calculated at once. When the line has been run by means of the angles of intersection, a north-and-south line is drawn on the paper, and the angles which all these short lines *A B*, *B C*, *C D*, etc., make with this line are calculated, and then the latitudes and departures worked from these.

The latitudes and departures may be taken directly from tables prepared for that purpose, called "Traverse Tables," or from tables of natural or logarithmic sines and cosines. These last are by far the more accurate, as the angles can be taken to each minute, while the ordinary traverse table only reads to every 15 minutes.

Where much work has to be done, it is an exceedingly slow and tedious operation to calculate all the latitudes and departures from either of the above-mentioned tables, and the following is a very rapid method, much used in actual work, and where proper care is exercised of sufficient accuracy.

Plate XXXIX represents what might be called a "Graphic Traverse Table," as manufactured by Keuffel & Esser, of New York. It consists of a sheet of tin about 18 in. square, divided by horizontal and vertical lines to any convenient scale, say one-tenth or one-twentieth of an

inch, as shown at *a b c*. Outside of this square and near the edge of the plate there is a protractor, *e f g*. *D T* is a straight-edge, one edge of which is divided into exactly the same scale as the plate. This straight-edge turns on a pivot at *P*, which is the point of intersection of the two sides of the square *h c* and *i a*. The side of the straight-edge upon which is the scale is in line with this point of intersection *P*.

The manner of use is as follows :

The straight-edge *D T* is set at the angle of departure by means of the protractor *e f g*. The length of the line is taken on the scale on the ruler, and the point where this comes on the plate noted. Then by reading off the distance of this point from the line *c h* upon the line *a i*, we have the latitude of the point, and by reading off its distance from the line *a i* upon the line *h c*, we have the departure.

For example, we have a line 100 ft. long with an angle of departure of 78°. Set the ruler at 78°, and note the position of the point 100 on the scale, which comes at the point *l*. Then we have the position of the point *l* on the

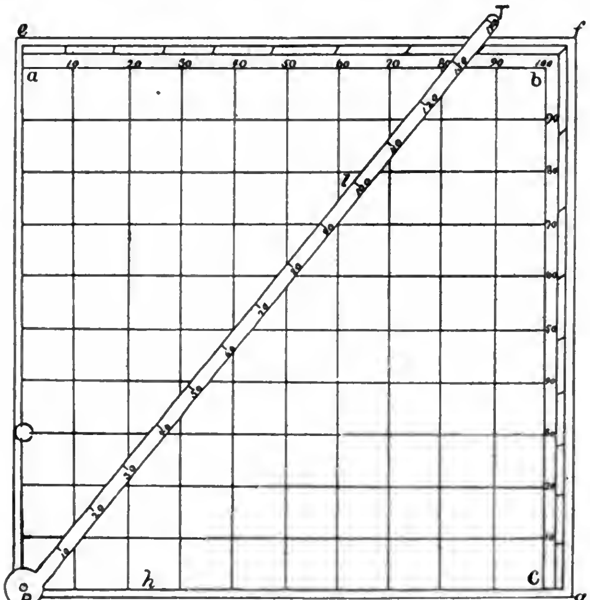


Fig. 1.

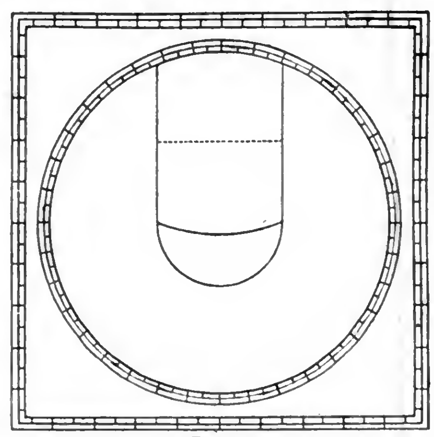


Fig. 2.

Fig. 3.

PLATE XXXIX.

scale *a i*, or its latitude, 78.8, and its departure or distance on the scale *h c* as 61.5+.

It takes two persons to calculate latitudes and departures by this method with rapidity and accuracy, one to read off the angles and distances and note the results, while the other manipulates the diagram and reads the results. One of the diagrams can be easily made by using a piece of cross-section paper and a paper scale, using care to have the zero on the paper scale at the point *P*, about which it turns.

The advantages of plotting a line of survey by means of latitudes and departures are the greater accuracy obtained and the less liability to error ; also the fact that any error that is made in plotting one line is confined to that line, or, at any rate, does not grow larger as the work advances, from the fact that each line is plotted not from the one which preceded it, but from parallel lines. The direction of each line is thus made entirely independent of what has gone before.

CHAPTER XIX.

CURVES.

As we have said before, the preliminary lines of a railroad survey are broken lines ; that is, they are made up of straight lines of greater or less length, forming different angles at their points of intersection, as shown in Plate XL, fig. 1.

On the final or permanent line of the railroad (the center line upon which it is built), all these angles are rounded off by means of curves of various radii, as shown in Plate XL, fig. 2. The usual curve is an arc of a circle, although in one case (the Festiniog Narrow Gauge Railroad in Wales) a parabolic curve has been used as being the theoretically correct curve ; that is, the curve which opposes the minimum resistance to the passage of a train.

Even this theory, however, is acknowledged to be inaccurate as to the actual resistance encountered by the train ; and another great objection to the general adoption of the parabola is the difficulties which occur in running in the curve. The curve which theoretically presents the least difficulty, both in laying out and in hauling trains around it, is a circular curve, with the ends eased off by one or the other of the different methods extant.

The subject of easing off the ends of curves, or, as it is termed, putting in "transition curves," will be taken up later. We will now take up only circular curves, showing the principles upon which their use is based ; the manner of calculating them ; the manner of laying them off in the field, with explanations of a few of the problems which occur with the greatest frequency in practice. For a full and elaborate treatise on the subject of railroad curves and all pertaining thereto, the reader is referred to the book on that subject by John C. Trautwine as being one of the best that is published, and also to Searles's "Field Engineering." Before explaining the manner of laying out curves in the field, we wish to call attention to a few definitions which the reader will do well to get firmly fixed in his memory.

In Plate XLI, fig. 1, let *A D C* and *B E C* represent two tangents or two parts of a preliminary line meeting at an angle at *C*. Then the angle *m C E* is called the angle of intersection. It is required to join these two tangents by a circular curve of any given radius. Let *D g h i k E* represent this curve and *F* the center of the curve ; then *D F* or *E F* is the radius of the curve.

The curve commences at *D* on the tangent *A D C*, which point *D* is called the "Point of Curve," and in the notes is designated by the letters "P. C."

The curve ends at *E* on the tangent *B E C*, which is

called the "Point of Tangent," and designated by the letters "P. T."

The distance from the angle of intersection C to the point D, where the curve begins, and the point E, where it ends, is called the "tangential distance."

The angle $D\,F\,E$ included between the radii $D\;F$ and $E\,F$, drawn from the points D and E or P. C. and P. T. of the curve is called the "Central Angle" of the curve, and is always equal to the angle of intersection $m\;C\;E$. The central angle is designated in the notes by "Δ."

A Chord is a straight line, shorter than the diameter of a circle, joining any two points in its circumference, as the line $i\,k$ or the line $D\,k$.

The Length of a curve is not measured exactly on its circumference, but by chords one station long. Thus, when a chain 100 ft. long is used, a curve is said to be, say, 700 ft. long when it contains seven stations of 100 ft. each, measured by chords 100 ft. long.

This measurement does not, of course, give the exact length of the curve, but always a little less, and the shorter the radius of the curve the greater the difference between the actual length and the length given by means of 100-ft. chords. But until the radius becomes less than 600 ft. the difference between the actual length and the length obtained by measuring with a 100-ft. chain is so small that it may be disregarded.

When the radius is less than 600 ft. the curve should be measured by chords of 50 ft. in length, and where the radius is less than 300 ft. by chords of 25 ft.

In speaking of railroad curves they are designated as curves of a certain number of degrees. Thus, a 6-degree curve, an 8-degree curve, etc.

By the degree of a curve is meant the central angle, which is subtended by a chord one station long (100 ft., or 20 meters, as the case may be).

Thus in Plate XLI, fig. 1, let $D\,g$ represent a chord 100 ft. long. Then the number of degrees and minutes in the angle $D\,F\,g$ subtended by this chord is the degree of the curve.*

* The common practice among English engineers is to take the radii of the curves a full number of feet, and then calculate the degree of curve. American engineers, on the contrary, usually take the degrees or the minutes, and calculate the radii.

To lay out a curve on the ground we must know the P. C. or starting point and the degree of curvature D. The length of the curve L is either calculated, as when two existing tangents are to be connected by it and the P. T. is known, or the P. T. is decided upon as the curve is fitted to the ground and the desirable direction of the next tangent becomes obvious.

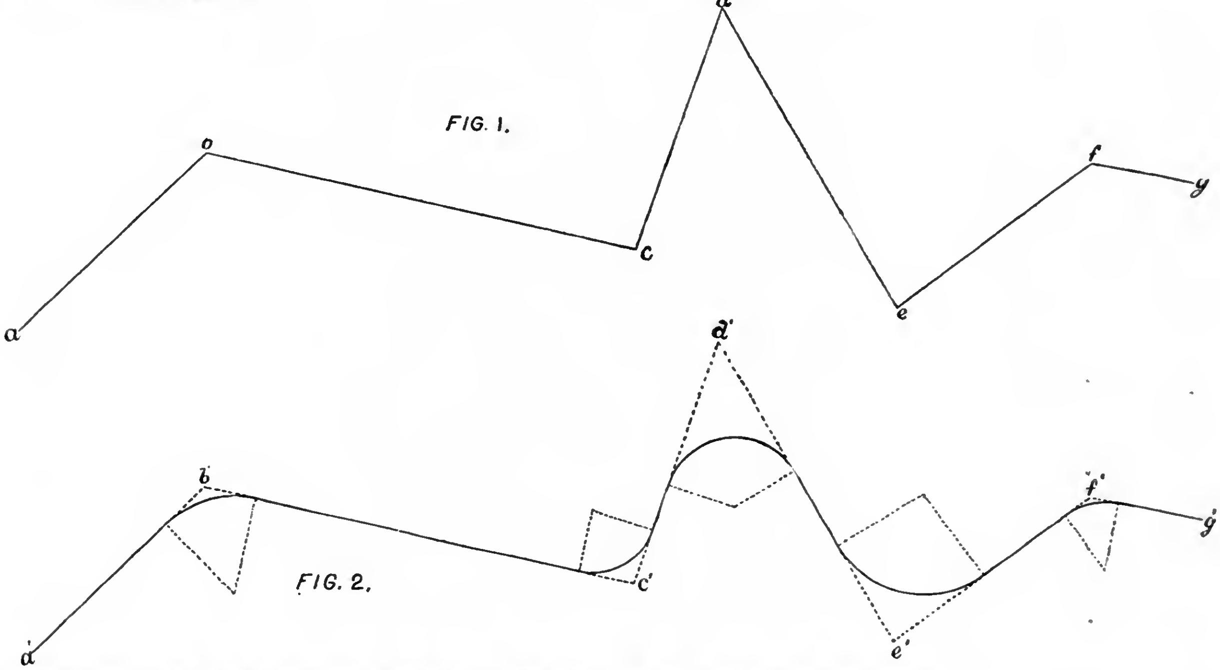
The distance $k\,c$ is called the "External Distance." It is the distance from the point of intersection of the tangent to the middle point of the curve.

The long chord is a straight line joining the P. C. and P. T.

The following letters will be used to designate the various elements of the curve opposite them.

Δ = Central angle, $D\,F\,E$, m C E.
D = Degree of curve.
L = Length of curve in stations.
R = Radius.
T = Tangent distance $D\,C$ or $C\,E$.
C = Long chord $D\,E$.

PLATE XL.



M = Middle ordinate $K\,O$.
PC = Point of curve, D.
PT = Point of tangent, E.

The following are some of the problems which occur in actual work with the greatest frequency :

(1) $L = \dfrac{\Delta}{D}$ (2) $\Delta = D\,L$ (3) $D = \dfrac{\Delta}{L}$

(4) $T = R \text{ tang. } \tfrac{1}{2}\,\Delta$ (5) $C = 2\,R \sin \tfrac{1}{2}\,\Delta$

(6) $M = R \text{ vers. } \tfrac{1}{2}\,\Delta$ (7) $E = R \text{ external sec. } \tfrac{1}{2}\,\Delta$

(8) $R = T \cot. \tfrac{1}{2}\,\Delta$ (9) $E = T \text{ tang. } \tfrac{1}{4}\,\Delta$

(10) $R = \dfrac{E}{\text{Ex. sec. } \tfrac{1}{2}\,\Delta}$ (11) $T = E \cot. \tfrac{1}{4}\,\Delta$

The above equations are taken from Searles's "Field Engineering," and present the simplest manner of calculating the different elements of the curve. In order to use these equations, of course, a table of sines, tangents, etc., is necessary; but as all engineering pocket-books contain these, they are, or should be, always at hand for use.

However, the student will see, upon a little study, that most of the above problems can be worked out by means of the properties of right-angled triangles.

We now come to the methods used in the field in putting the curve on the ground, Plate XLI, fig. 2.

Let *A B* be the tangent and *B* the point of curve, P. C.; the degree of curvature *D* has been decided upon. Set the transit up at *B*, with the zeros of the two plates together. Then sight back on the tangent to some point *A*, *o B c* is called the tangential angle. Move the transit to *c*, place the zeroes together, and sight back on *B*. Then reverse the telescope and turn off the full angle of the curve *m c d* or twice *A b c* and line in the point *d*, one station from *c*.

Proceed in a like manner to establish the points *e* and *T*.

PLATE XLII.

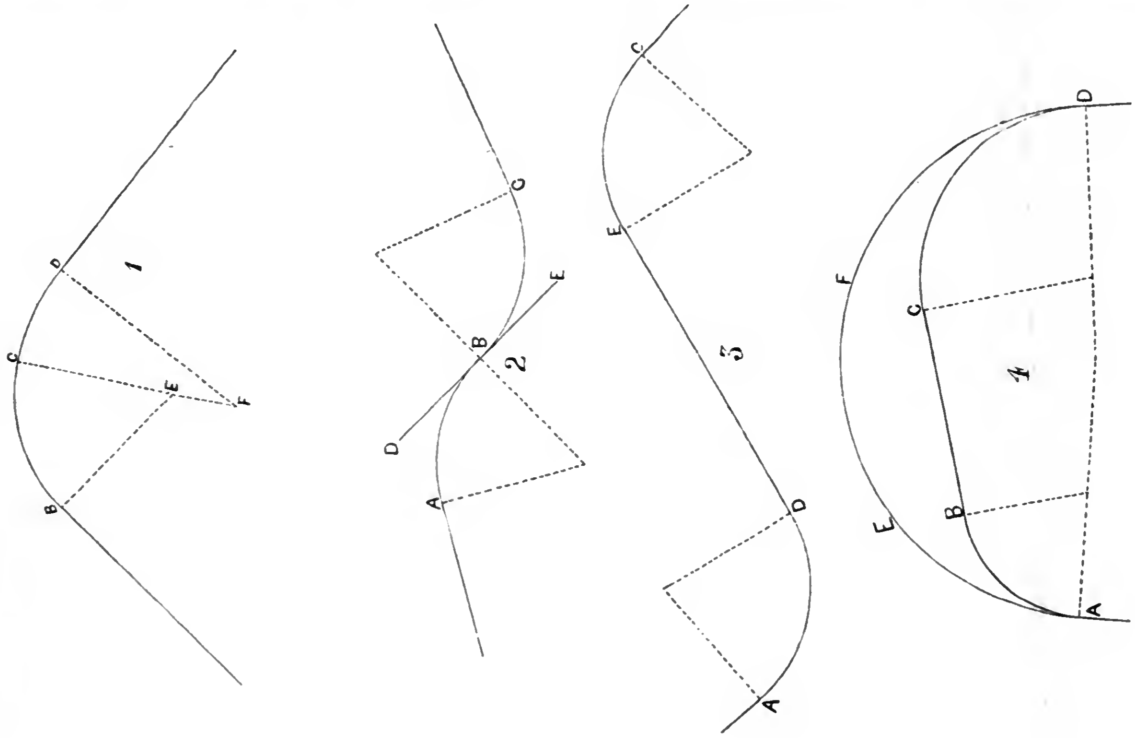
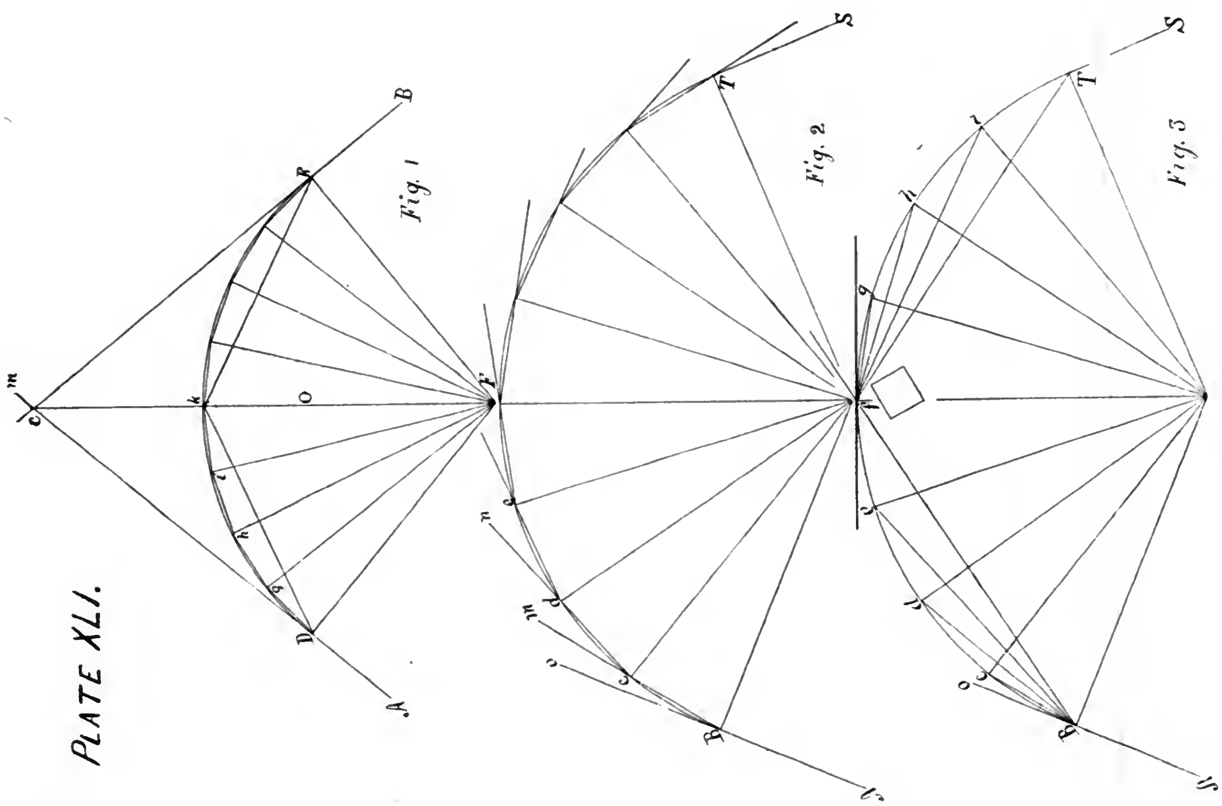


PLATE XLI.



and set the telescope on it. Reverse the telescope, and we are ready to commence the curve.

The stakes are to be put in every station. Turn off the angle *o B c* equal to ½ the angle of the curve, ½ *D* and line in the point *c* one station from *B*. This angle

T represents the point of tangent. In order to pass from the curve to the tangent, set the transit at *T*, sight back on *e*, reverse the telescope, and then turn off the angle *T* equal to ½ *D*, and it will give the direction of the new tangent. In running in the curve the angles *m c d*, *n d e*,

etc., are called deflection angles, and are all equal to D. This method is called running in a curve by means of "deflection angles," and is used to a less extent than the following from the fact that, the transit having to be moved each station, much time is lost.

The second method for running in curves, and the one used whenever possible, is by means of tangential angles, and is as follows, Plate XLI, fig. 3.

Let $A B$ be a tangent and B the point of curve. Set the transit at B, with the zeroes together, and take a back sight at A. Reverse the telescope and turn off the angle $A B c$ equal to $\frac{1}{2}$ D and line in station c. Then turn off the angles $c B d$, $d B e$, $c B f$ in succession, each equal to $o B c$ (equal to $\frac{1}{2}$ D), and line in the points $e f$, etc., and all these points will be upon the circumference of the required circle. In case the curve is not too long and there is no obstacle in the way, this process can be continued until T, the point of tangent, is reached. But if between B and g there is some obstacle, or the distance is so great that a good clear sight is impossible, then move the transit to f, with the plates clamped, as when lining in the point f. Take a back sight on B and turn the upper plate until the zeroes coincide, and the telescope will be on the tangent of the curve at the point f. Then proceed as before, and run in the points g h i and T. When the point T is reached, and it is required to get the direction of the new tangent $T S$, proceed exactly as at f—that is, with the plates clamped at the angle $k f$ T, and sight back on f, reverse the telescope, and turn the upper plate until the zeroes coincide, and the telescope will be on the line of the new tangent $T S$.

If at any point on the curve it is necessary to set intermediate stations at, say, half or quarter stations, then the angle to be turned off bears the same relation to the angle that would be turned off for a full station that the length of this sub-station bears to the length of a full station; that is, for half a station we would turn off half the angle; for a quarter of a station, one quarter the chord.

It very often happens that at both the beginning and ending of a curve the use of sub-stations is necessary.

CHAPTER XX.

COMPOUND AND REVERSED CURVES.

In order to fit the line better to the ground it is often necessary to use what are called COMPOUND CURVES—that is, a curve made up of any number of simple curves of different radii. Thus, in Plate XLII, fig. 1, $B C D$ is a compound curve, being composed of the curve B C with the radius $B E$ and the curve $C D$ with the radius $F D$. In changing from a curve of one radius to one of another radius the point of compound curvature designated by the letters "P. C. C." must be a point where a tangent to one of the curves will also be tangent to the other, as the point C. In other words, the radii of two curves at their point of contact will coincide in all except length.

A REVERSED CURVE is composed of two curves of opposite direction that have a common tangent at the point where they meet, as shown in Plate XLII, fig. 2, where $A B C$ is a reversed curve, the line D E being tangent to both at the point B, where they meet.

In practice reversed curves proper should never be used where it is possible to avoid it, owing to the fact that, the direction changing at once from right to left, or *vice versa*, it is impossible to give the outer rail of each or either curve the proper elevation. Either the change from the elevation of the rail on one side to that on the other must be made very abruptly, or a long distance on each curve will have insufficient elevation. As the ease and steadiness with which a train will pass around a curve depend to a great extent upon the correct superelevation being given to the outside rail, the great objection to reversed curves is due to the impossibility of doing this, and the consequent jarring and wrenching to which the rolling stock is subjected increases to a great extent the wear and tear on both rolling stock and road-bed, and therefore the cost of repairs and renewals.

The increased resistance to the passage of the train due to the change of direction in the curve amounts to very much less than has heretofore been calculated. Wherever it is necessary that the direction of the curve should change from one side to the other, there should always, when possible, be a piece of tangent of not less than 300 or 400 ft. introduced between them. This gives an opportunity for the train to straighten out and also for the change in the superelevation of the outside rail to be made in the proper manner, as shown in Plate XLII, fig. 3.

In the case of "turnouts" and "cross-overs," of course reverse curves must be used in order to economize space, and in those cases they are perfectly admissible and do little harm to the train, as, from the necessities of the case, trains are obliged to run at a reduced rate of speed over them.

There is another class of curves against the use of which there is a strong prejudice among the older engineers, and that is what is called a broken-back curve. In Plate XLII, fig. 4, $A B C D$ is a broken-back curve—that is, two curves in the same direction, connected by a short piece of tangent. The curve does not look as well on the ground as the continuous curve $A E F D$, but this is the only inherent objection to its use over a continuous curve that the author has been able to find, and where it will fit the ground better than a continuous curve it should by all means be used.

(TO BE CONTINUED.)

The Oschutz Viaduct.

(Translated from the *Revue Generale des Chemins de Fer.*)

THE railroad line, of standard gauge, from Mehlteuer to Weida, in Saxony, crosses the valley of the Oschutz by an iron viaduct, which has now been for some time in use by trains.

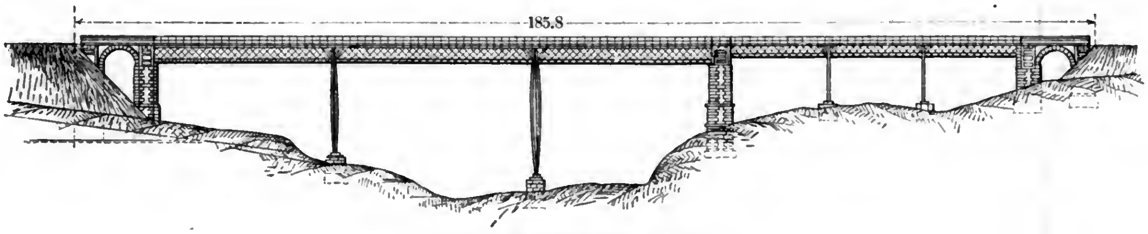
The viaduct across the principal valley is formed by a continuous girder of 333 ft. in length, forming three spans of 106.5, 120, and 106.5 ft. in length; the smaller or secondary valley is spanned by a shorter continuous girder of only 177 ft., divided into three spans of 59 ft. each in length. At the two ends of the viaduct are abutments of masonry, and an intermediate pier, also of masonry, serves as an abutment common to both continuous girders. The short intermediate piers are formed by oscillating pillars or towers of iron, and these oscillating pillars are the peculiarity of the work. Owing to the joints on which these piers move, they can follow the longitudinal movement of the girders, caused by the passage of trains or by contraction and expansion.

The accompanying sketch shows in fig. 1 a general view of the bridge on a small scale; and in fig. 2, on a larger scale, the construction of one of the oscillating piers. The dimensions on these cuts are in meters and millimeters.

Similar oscillating piers have already been used in the construction of the viaducts at Lysedalen, Solbergdalen, and Haabolbach in Norway, but the arrangement of the joints and the details of construction of the piers in those

works were different from those of the bridge which is now described.

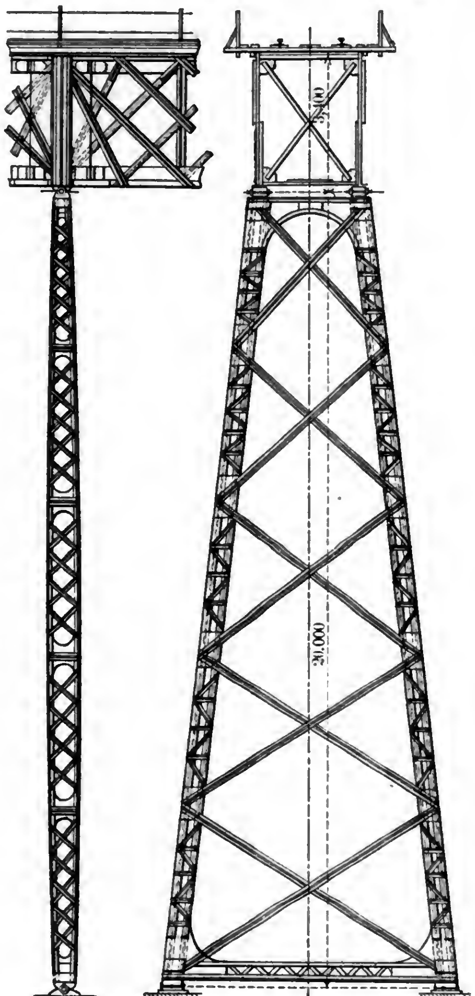
The abutment common to the two girders is 52½ ft. high above the ground, and has a transverse section of about 248 sq. ft. The abutments at the ends of the viaduct are each formed of sandstone arches. The sockets of the lower joints of the iron piers are of granite, and in their foundations are openings, which permit of an easy inspection of the condition of the joints.



THE OSCHUTZ VIADUCT.

(*Dimensions in Meters.*)

The track is of steel rails placed on longitudinal sleepers of rolled iron. The sleepers and the rails are of the same length, 24½ ft. On the abutment common to the two girders of the viaduct there is an apparatus of the Klette system, to permit the expansion and contraction of the girders.



PIER FOR THE OSCHUTZ VIADUCT.

(*Dimensions in Meters.*)

The large girder is 9.8 ft. in height between the axes of its horizontal members; for the short girder the corresponding height is 4.9 ft. The large girder weighs about 333,000 lbs., or about 1,000 lbs. to a running foot; the weight of the smaller one is 141,000 lbs., or about 800 lbs. to the running foot.

One of the two intermediate piers supporting the large girder is 52½ ft. and the other 65½ ft. in height; those of the smaller girders are both 26 ft. in height. The profile of these piers is that of columns swelled out in the middle. Each is composed of two similar columns, which are joined together by counterbracing, in order to give them sufficient resistance to the action of the wind, the greatest possible pressure of which is assumed at 31 lbs. to the square foot. The inclination of the members of the large columns is 1 in 9; of the small columns 1 in 6. The large columns have rectangular sections and the small ones cylindrical. The form of the columns enlarged in the middle was adopted for the reason that the wind pressure increases considerably the longitudinal compression; and also because experience in America and England has shown that the longitudinal compression of long columns is not to be feared when the mean diameter of the column is not less than $\frac{1}{30}$ of its height. The transverse elevation of the piers in fig. 2 shows that the counter-bracing is sufficient to give the desired security against compression.

In building the bridge, the small viaduct was first erected and then the larger one. The iron pier of 65½ ft. in length was erected in three pieces, that of 52½ ft. in two pieces, and the short ones in a single piece. Wooden scaffolding supported the piers during the erection. The total weight of iron entering into the construction of the viaduct is 255 tons. The work on the bridge occupied in all 8 months, the actual erection taking 13 weeks.

The cost of the bridge was $50,400—that is, as the engineers calculated, about $1.50 per square foot of the profile of the valley.

THE FIRST DESIGN FOR A BRIDGE OVER THE HUDSON.

ONE of the earliest works on bridge construction published in this country—in fact, the first of which we have any knowledge, was a "Treatise on Bridge Architecture," published in New York, in 1811, by Thomas Pope, who describes himself as "architect and landscape gardener." A copy of this book, which is now very rare, has come into our hands through the courtesy of a subscriber. Mr. Pope might also have added "poet" to his titles, for he not only has a habit, somewhat startling in a scientific work, of dropping into poetry upon any occasion, but he concludes his book with a poem some eight or ten pages long, in heroic measure, intended to impress upon the readers the merits of his favorite design. About one half of his book is devoted to a history of bridges, containing descriptions of many of the noted bridges, both ancient and modern, which had been built up to his time, in all parts of the world, Europe and Asia as well as in America. This part of the work is profusely illustrated, and the Author evidently had more artistic than poetic taste, for the engravings are of remarkable excellence for that period, when the art was in a very much lower state of development than it has since reached.

In addition to this history of bridges, we have some general remarks on the Nature and Strength of Timber, the best methods of cutting and using it, etc., which tend to show that he had a considerable practical knowledge of

this subject. The remainder of the book is devoted to a description of the "Flying Pendant Lever Bridge," invented and patented by the Author, and on this part he has evidently expended the greatest amount of labor.

In this pattern of bridge he evidently felt the fullest confidence, for in his treatise, in addition to the description and general plan, he gives estimates and designs for bridges from 200 up to 2,400 ft. span. In this connection he presents a design for a bridge across the Hudson River, which is undoubtedly the first definite design ever presented for spanning that stream; and although it differs widely from the Poughkeepsie Bridge and from other later proposed structures over that river, it has seemed to us of sufficient interest to our readers to reproduce the engraving of the proposed bridge which its designer has left us, and also some notes as to his description.

It will be seen from the engraving that Mr. Pope proposed to span the river with a single arch of timber resting on heavy abutments. Upon the construction and elaborate argument arranged in propositions and scholia, in the somewhat pedantic fashion of the day. His argument as a whole is too long to be here reproduced; but some of the advantages which he claimed are: That his bridge is founded upon clear and distinct geometrical principles; that the required strength could by his plan be obtained with a less expenditure of material than in any other way; that very little bracing would be needed to resist the wind pressure, as the frame of the bridge itself constitutes almost sufficient bracing; and lastly, that an arch of this kind could be built out from the two ends without false-work or framing of any kind, as when the ends were once firmly secured in the abutments the framed timbers could be added piece by piece, until the two ends of the arch should meet in the center. He also claimed that at any time when necessary for repairs, or for any other purpose, a section of the bridge 40, 50 or more feet in length might be taken out in the center in a very short time and replaced almost as quickly. The timbers re-

VIEW OF T.POPES FLYING LEVER BRIDGE.

Let the Broad Arch the spacious Hudson stride,
And span Columbias Rivers much more wide.
Convince the World America begins,
To foster Arts the ancient work of Kings.

solidity of these abutments he laid great stress; but he did not intend that they should be merely masses of masonry, useless for any other purpose than a support to the bridge. By a system of arches and buttresses he proposed to construct them in such manner that they would serve the purpose of abutments and could also be used as warehouses, thus anticipating by some 60 years the plan actually adopted for turning to advantage the vacant spaces under the arches of the Brooklyn Bridge.

The bridge itself, as indicated by the engraving, was to be of timber, securely framed and dovetailed together, forming two flat arches upon which a roadway was to rest. The arrangement of the timbers in these arches, he claimed, was such as to secure at once strength and lightness; while the timbers were so placed that as each was put in position, it served not only to lock back and secure those already in the arch, but also to furnish a new fulcrum or support for the additional timbers.

Mr. Pope sets forth the excellences of his design by an quired could all be cut of proper size, framed and prepared before putting in place, so that the actual erection of such a bridge could be very quickly done.

The roadway could be carried either on top of the structure or between the ribs; and in the latter position the bridge could be roofed over, thus fully preserving it from the weather. Many other advantages are named, but these comprise the principal ones.

We are not aware that Mr. Pope's arguments, however, were successful in convincing the capitalists of his day, and, so far as we know, no bridge on the "Flying Pendant Lever" plan was ever actually constructed, even on a small scale. If so, it was not any fault of the Author, who evidently had the utmost confidence in himself and his plan, and would doubtless have been willing to prove its excellence not only by scientific syllogisms, but by actual practice, if the opportunity were afforded him.

Mr. Pope seems to have had an excellent opinion of himself, for in the commencement of his account of the

method for constructing the bridge he says : "The mode of constructing a bridge on this important invention is perhaps the most singular and also the most simple thing that has ever entered the mind of man." As a further example of his confidence in his own powers, we quote the summing up of his argument as follows :

EXTENT.—From a recollection of the many absurd opinions lavished on this invention, at its first promulgation, by characters the least to be expected, namely, of those who profess a vast knowledge in science, the author has been ready to conclude that he would suspend for the present any information on this important part of the subject ; preferring rather to wait the period when ocular demonstration should sufficiently punish the gross ignorance of these pretenders to science and enemies to the useful arts.

But the Author has also considered that if a Bridge on this plan be indeed capable of the vast extent he has heretofore asserted, and which, from a multiplied conviction of the excellence of its principles, he still dares to assert ; how dishonorable would it be on his part, were he to shrink from the just vindication of its true merits because a mere quack philosopher and two or three bookful theorists (who may be looked up to by some as *Gods in Science*, but who are in reality of those that are the pests of the arts in every age)—because these, in the plentitude of their wisdom, may think fit to doubt the existence of the vast powers vested in this invention, without having once investigated even one of its golden properties.

The narrow limits that persons of this description have been disposed to fix for the utmost extent of a Bridge on this plan have at once evinced to the candid and intelligent part of the public, who have chosen to judge for themselves, that these sage persons were certainly under the influence of one of two things ; namely, a total ignorance of the invention, or a contemptible opposition to its success.

But, as the sons of science in all ages have ever had such characters to contend with, the Author conceives it a waste of time, at the present, further to notice such pusillanimous conduct. He therefore shall pass on to explain to the undissembled friends of science the grand reasons why a Bridge on this superior plan can be erected to a far greater distance with a single arc than any heretofore invented.

As a specimen of Mr. Pope's poetic powers, and also, perhaps, to show our modern writers on engineering how their works might be enlivened, we give below several extracts from the poem with which the book closes. The first four lines of the poem will be found repeated beneath the engraving.

The arms of Bridge are built of stone or wood,
But iron, cast, would furnish twice the good ;
Its extra beauty and its lesser weight
Confound the pride and ignorance of the great.
Combining levers stretch from shore to shore,
And span the foaming flood ne'er span'd before ;
By logs of timber plac'd at angles right
The bold formation is made strong and tight ;
Each semi-arc is built from off the top,
Without the help of scaffold, pier, or prop ;
By skids and cranes each part is lower'd down,
And on the timber's end-grain rests so sound,
That all the force of weight can ne'er divide
Each tabled timber from its partner's side :
And, lest the end-grain should not stand the test,
A sheet of iron's plac'd between each rest,
That no compression or indention can
Make an impression to defeat the plan.
* * * * * * *
If shores supply with rock to build upon,
The builder then hath an advantage won,
By which he saves the cost that oft ensues
In sinking coffers, caissons, or mud-pews.
But should some softer strata heave in sight,
The consequences will be truly light,
As nothing is more easy to provide
Than concave circle on the under side,
By which the pressure will combine to force
The neighboring infirm strata much more close ;
Its watery particles must soon escape,
And force the solid grains into a heap,
By which the massy butment rests secure,
And through its firm foundation must endure.
* * * * * * *
When Time, with hungry teeth, has wrought decay,
Then what will sceptics be disposed to say ?
Why, "Down the Bridge must fall, without repair,
And all the Author's pleadings will be air."
Not so, he's better arm'd than you expect,
For nought can bring to ruin but neglect ;
A mean's provided, which can never fail,
To keep up strength whate'er the Bridge may ail :
Each log of wood, where'er its station be,
Is safely shifted for a sounder tree,
With greater ease remov'd than heretofore
A piece could be repair'd in an old floor.
* * * * * * *
The Author's Bridge shall surely rise to fame,
In spite of envy's efforts, power, or claim,
And men of liberal science own its worth,
Respect his name and cultivate its growth.

In justice to Mr. Pope it must be said that the prose of his book is better than the poetry, and he was evidently, if not an eminent engineer, at least a student and a careful compiler.

NOTES ON THE SEWERAGE OF CITIES.

(Translated from paper of M. Daniel E. Mayer, Engineer, in the *Annales des Ponts et Chaussées.*)

I.—NEW IMPORTANCE OF THE QUESTION OF SEWERS.

FORMERLY but few sewers were built, and those were only intended to carry off the rain-water which fell in the streets.

To-day, however, new demands have arisen in the hygienic administration of cities.

That pure drinking water is a primary necessity of health has been fully demonstrated. Hence, every collection of people deriving its supply of water from wells fed by a subterranean stream or basin, implies the necessity of preventing the pollution of this basin by the infiltration of foul water, whether the result of the ordinary processes of life or the refuse of manufactures.

Hence, the idea of providing channels to carry off this polluted water.

It is true that the system of supplying houses with water from small wells is inconvenient and insufficient, and that the tendency of every collection of people in a town or city is to provide for a public supply of water.

This step of progress, however, the most useful of all to the public health, does not do away with the necessity of providing channels of escape for the foul water, which would otherwise either soak into the ground or pour into the gutters of the streets.

It can even be said that, from a certain point of view, the public distribution of water and the suppression of wells render even more pressing the necessity of sewers. In fact, the subterranean streams or basins, whose level was before kept down and regulated by the wells, tend toward a higher and a variable level. In their rise they impregnate the organic matter contained in the soil of cities ; and when they fall this detritus, left to dry, ferments. The results are so serious that in several countries a relation has been observed between the rise and fall of these subterranean waters and the prevalence of epidemic diseases.

Notably in Munich and Vienna we have seen the municipal administrations occupied with this question. Now sewers preserve the soil from pollution by these germs of infection, and sometimes are used to lower and regulate the subterranean streams.

Another matter is involved in the introduction of city sewers ; it is one still much in controversy, but in our eyes one of the most important. If we wish to suppress, even in the poorest houses, those privies which render the

dwellings to which they are attached both disagreeable and unhealthy, and to replace them by water-closets which can be abundantly flushed,* it is necessary that the disposal of the waste water shall not cost, as it will by the system of cesspools, 10 or 20 times as much as the introduction of pure water. This waste water can be disposed of economically only by sewers. One can hardly count the cities in England and Germany where this system works without inconvenience; this is why, without intending disrespect to those eminent men in France who are opposed to it, we do not doubt that it will finally prevail; as well as the process of purification of polluted water by the soil, of which Paris has shown one of the earliest and best examples, and which Berlin has applied with success.

The sewer problem, then, has taken a new and more general character. It is no longer a question of building an isolated channel to drain a spot of low ground or to keep some main street dry. It will be necessary to make general plans, and to lay out a system of sewers as complete as the system of streets. To the self-interest of the cities will be joined the outside pressure from the Government, which desires to prevent the pollution of the rivers.

As a rule, these questions belong to the municipal administrations, which do not devolve upon engineers. But, even outside of the large cities, like Paris, where the public works are under the charge of the engineers of the *Corps des Ponts et Chaussées*, those engineers will have to interfere in the question of sewers, either in connection with their duties in charge of the roads, or as consulting engineers of the Government. It will not be useless, therefore, if in this matter, still comparatively new here, we consider and lay down certain rules, based on the nature of the subject itself and on the experience of other countries.

II.—FUNCTIONS OF A CITY SEWER.

In Paris the subterranean galleries which go under the name of sewers serve many uses. They contain the water-pipes, of which there are two in each street, their diameter being sometimes as great as 1.10 meters. There are placed in them also pneumatic tubes, the telegraph wires, the electric cables, etc., etc., which are thus made accessible at all times without disturbing the public roadways. In Paris, where the streets are comparatively narrow and there is an enormous traffic, this advantage is very valuable. It is for this reason that this subterranean system, the first conception of which is due to the great engineer Belgrand, is of incontestable utility in that city; and the systems for distributing heat, light, and power are now disputing for possession of the little space which still remains to be disposed of.

But such a system of sewers, admirably adapted to Paris, would be inadmissible in an ordinary city. Of the large cities in England and Germany, which have recently been provided with a system of sewers, there is not one where the idea has been advocated of following the great but necessarily unique example of Paris. This example also would be fatal in the smaller French cities, if they should make the mistake of attempting to follow it.

The reason is that while the surprising accessibility of the types of sewers used in Paris is excellent, the attempt to construct in small cities passages high enough to permit the passage of a man would lead to results too costly for their finances.

It is also probable that, in designing a system of public works for a large city, it would be better to provide tunnels apart from the sewers for the water-pipes, steam-pipes, wires, etc.

The amount per inhabitant which can be drawn upon yearly is usually much less in the provincial cities than in Paris. In Paris the yearly budget of the city is over 100 francs per inhabitant; but this is three times as much as in most of the provincial cities. The figures continually tend to become smaller as the collection of people is smaller and less important. On the other hand, what may be called the urban density—that is, the population per unit of surface—is much greater in Paris, so that a kilometer of sewer in a small city serves a much smaller number of inhabitants than in Paris. Unless we make the important fraction of the yearly expenditure which Paris devotes to the sewers five to ten times as great in a smaller city, which would have disastrous results, it is necessary that a kilometer of sewer should cost five to ten times less in those cities than in Paris.

This result cannot be attained by admitting Parisian types with the dimension reduced by a few centimeters; there must be a radical change of the system.

It must be admitted, in the first place, that sewers, as their name would show, have for their essential function the discharge of waste waters; and that the size of these works should be rigorously adapted to the duty which they must perform. This principle will permit us to make in smaller towns channels very much less costly than those in Paris.

It may be said, the application of this principle will compel us to make, in less important towns, very small sewers inaccessible to workmen.

In order that these should not be obstructed, it will be necessary to give up the Parisian habit of considering the sewers convenient receptacles for everything, for which there is no place on the surface, such as garbage, refuse of factories and slaughter-houses, street sweepings, sand, etc., etc. Without doubt it is very convenient to clean out a house or the street by throwing everything into the sewer; but this convenience must be paid for by an enormous increase of expense, both in the first construction of the sewers and in keeping them clean.

The sewer should receive all the waste water, but nothing but the water. This is a rule easy to lay down but not so easy to enforce; what rules and what police will be necessary for the purpose?

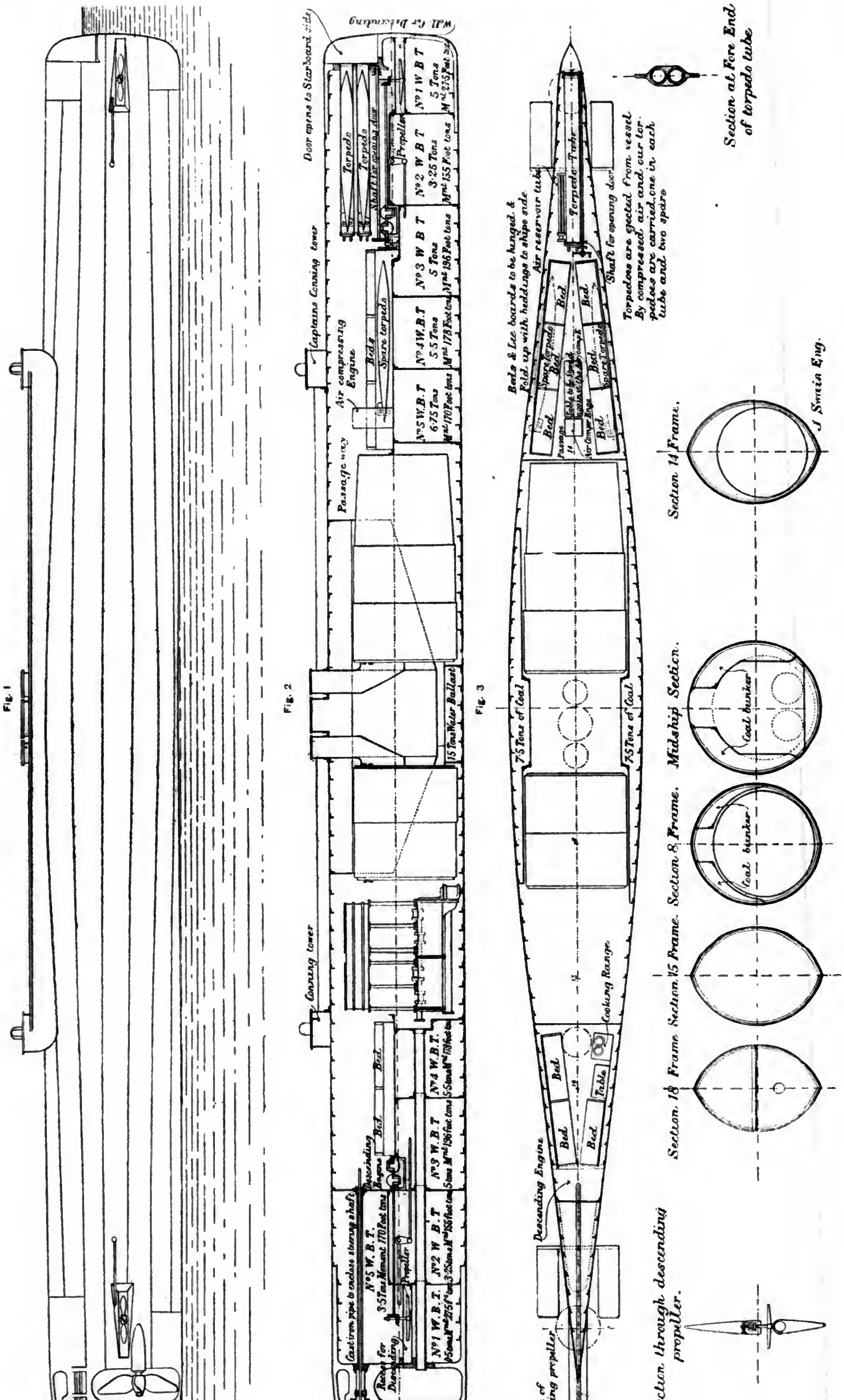
There is happily a method more sure than rules and less costly than a policeman; it is not a recent invention, for we believe that Hero, who lived in Alexandria 150 B.C., knew of it. It is the siphon. If we place at the points of communication between the house or the street and the sewer a reversed siphon, heavy and bulky bodies will not be able to pass through it. If it is in a house they will obstruct the connection, the maintenance of which is charged upon the house-owner, and he will be at once warned of his carelessness and punished for it. If it is in a street, such bodies will be retained or will be deposited in the connections, and the street cleaners, who will be obliged to remove them, will soon learn to be careful in this respect.

We forbid in an absolute manner this system of throwing everything into the sewer; but there is an exception to this rule, which must necessarily be made. There is a certain class of refuse (excrementitious matter) which can be carried off in the sewers, on condition that the closets are supplied abundantly with water, because when this condition is complied with, this refuse reaches the sewer in a liquid condition and sufficiently diluted to pass off without interruption. In view of the controversy to which this question has given rise, it is interesting to observe that, after all, it is not necessary to consider it seriously in deciding on the plan and conditions of a system of sewers. The fact is, that the amount of water coming from water-closets is relatively smaller in comparison to the total discharge by which the capacity of the work must be fixed; and, as to the measures taken to secure a regular flow and to prevent deposits, the existence of foul water which usually becomes a source of disease would be sufficient, either with or without the admission of water for flushing the sewers, to render such precaution altogether indispensable, even where no water-closets exist.

An eminent English engineer, Mr. Lindley, who has designed some important works of this kind in Germany, having been asked by the authorities of Eberfeld to present two plans for sewerage of that city, one with and the other without the admission of water from closets, answered, with good reason, that a single plan would be sufficient, because the system of sewers would be the same in either case.

(TO BE CONTINUED.)

* It is hardly necessary to note that in this country there is no longer any controversy as to the superiority of the water-closet over the privy-vault from a hygienic point of view, although M. Mayer seems to imply that there still is in France.—EDITOR.



THE NORDENFELT SUBMARINE TORPEDO BOAT.

The Nordenfelt Submarine Torpedo Boat.

(From the London *Engineer.*)

THE accompanying illustrations show the Nordenfelt submarine boat, "No. 4," which was tried in the presence of Government officials and foreign attachés at Southampton on December 19 last. The form is entirely changed from the cigar or double conical shape of the preceding patterns. The cross-section midships is now an exact circle, which closes as it moves toward bows and stern, passing through a double ogival or Gothic arch, which narrows more and more until it ends in a vertical line forming each actual end of the boat. This form does not cause the boat to be subject to the same eccentric and dangerous effects as were produced with the cigar shape, notably in suddenly stopping, as has been found necessary for fear of fouling some vessel, as occurred in the trial in the Bosphorus. The cupolas or "conning towers" shown furnish the means of entrance into the hull of the boat, and remain available for this purpose until the boat is submerged to the level of the surface of the superstructure, as shown in the highest long horizontal line in figs. 1 and 2.

The captain and part of the crew occupy the stern end of the boat, and the engineers the forward part; the engines are amidships. The captain can communicate with the men forward by speaking tubes, and has the working of the boat in complete control, having at his hand the gear for all movement, and for revolution or stoppage of propellers, shown in fig. 1, and for the horizontal screws shown in fig. 2, which cause the boat to descend or rise. The crew, in fact, have no means of knowing whether the boat is on the surface or below, when once the cupolas are closed, with the exception of the men who enter their heads into the glass domes at the apices of the two cupolas or conning towers. Generally, the captain occupies the stern dome, and one of the engineers the forward one, while the boat is being adjusted to any desired position. The two portions of the crew are not cut off from each other, as there is a passage over the boilers through which a man can creep. For submarine action, the chimneys are removed amidships, and covers are closed over the openings, the glass domes are tightened over the manholes in the cupolas, and the crew then are dependent on the stores of air and steam that are contained or provided for in the boat, whether on the surface or below water. This state of things has been maintained for eight hours at a time, although the boat is generally wholly submerged for only a short part of that time. The boat is adjusted for submarine action to float with the superstructure level with the surface of the water. The horizontal screws then by their revolution keep the boat beneath the surface; and if the engines stop from any cause, the boat rises to a position in which the crew could escape through the manholes of the cupolas. Torpedoes are discharged from the bows of the boat a little above the horizontal screw. Three torpedoes are shown in fig. 2 at the bows. Mr. Nordenfelt proposes to make much heavier torpedoes than those of the present Whitehead pattern. Thus in attacking a ship, the *Nordenfelt* would have two advantages over an ordinary torpedo boat. She might expect to approach much closer before discharging her torpedoes, and thus she might hope to send two torpedoes in succession on to the same spot. This, in the case of having to effect a passage through protecting netting, would be a great advantage, as the first torpedo would open a way which would only be available for another following exactly in the same path. Then the increased weight and momentum of Nordenfelt's torpedo, although its speed would be less, would carry it through obstacles better than the lighter pattern.

Nordenfelt has made the boat strong enough to resist the pressure of water to 60 ft. depth. This appears to be sufficient for all practical purposes, especially as the boat might generally be used in defending passages where the depth is not considerable. It must be apparent, however, that the physical conditions under which the boat works are novel in many respects, and call for special nerve, skill, and experience, especially in the captain, in whose hands the boat is placed in so exceptional a way.

THE ZALINSKI PNEUMATIC TORPEDO GUN.

AT the December meeting of the United States Naval Institute in Annapolis, Captain E. L. Zalinski, U.S.A., read a very interesting paper on the "Naval Uses of the Pneumatic Torpedo Gun." We give below some extracts from this paper, for which, and for the accompanying illustrations, we are indebted to the courtesy of the Institute.

THE GUN.

The gun-barrel consists of a very light tube having, at present, a smooth bore. As the firing pressure used does not exceed 1,000 lbs. per square inch, it will be seen that, if made of steel or aluminum bronze, it need not be more than ½ in. thick even in calibers as great as 20 in.; a greater thickness has been used in the 8-in. and 15-in. guns, for the purpose of obtaining somewhat greater rigidity and to lessen the chances of mechanical injury in transportation and manipulation. Where it is important to eliminate weight, as on shipboard or on torpedo boats, these tubes can be made very light indeed, especially in cases where they are placed at a fixed angle.

When the machine is to be movable for elevation or direction, or both, the barrel is supported on a suitable truss.

The breech mechanism is ordinarily a simple gate arranged so that the valve mechanism cannot function until the breech is closed and latched.

THE VALVE.

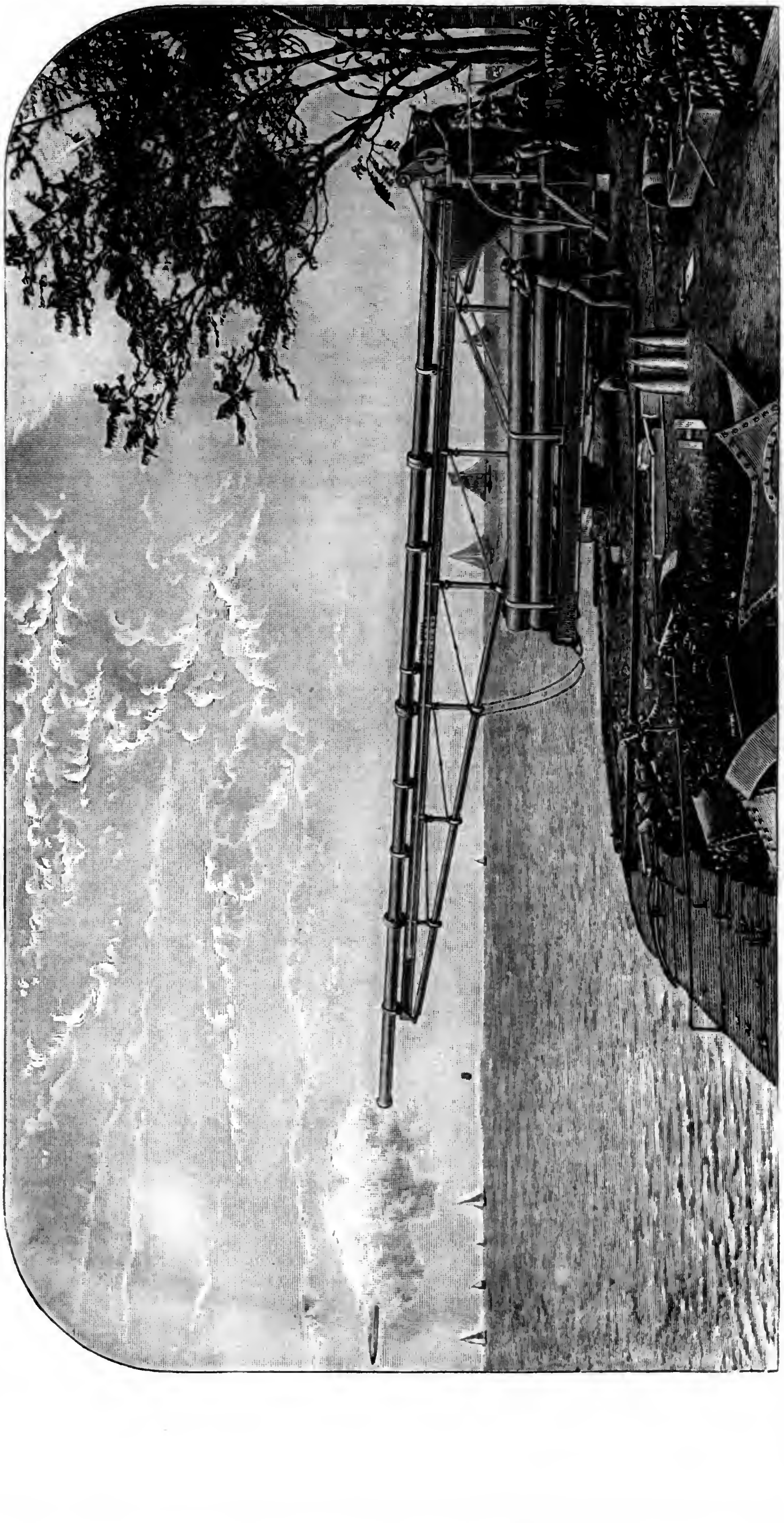
The valve is known as a balanced valve, so arranged as to open and close by a single movement of the operator. The time of opening and closing can be varied by an adjusting device so that any desired loss of pressure will ensue. In this way the range can be changed without change either of elevation or pressure. In addition to this means of controlling the range, there is a device for throttling the passage-way between the valve and the reservoir of the gun, so that although the valve may open and close in a uniform time, the amount of air which can pass into the gun in that time can be varied. A more complete and accurate control of the range can be obtained in this way than in any other. The size of the passage-way can be quickly regulated to a hair's breadth. In the case of a vessel advancing or retreating from a target, the opening can be constantly changed to conform to the variations of range, much more quickly and accurately than can be accomplished by corresponding changes of elevation of a gun. The accompanying engraving represents the 8-in. gun in position on land.

THE RESERVOIRS.

The air reservoirs used thus far consist of wrought-iron lap-welded tubes of 12¾ in. and 16 in. outside diameter, and from ¼ to ¾ in. thick. These tubes are from 18 to 20 ft. in length. The reservoir tubes from which the air for firing is directly drawn are known as the "firing reservoirs." This reservoir will, as a rule, have five times the capacity of the bore of the gun. Experiments are under way with a view of producing very light reservoirs, both by wire-winding and by cold drawing of brass and steel.

It may be well to mention here that the pressure in the reservoir may be reduced by a single firing to any predetermined amount, the valve being adjustable to accomplish this automatically. The most economical results are obtained with the air acting expansively. A loss of 10 per cent. to 12 per cent. with a reservoir of 5 capacities of the gun bore is the maximum which can be used with any appreciable advantage.

Where it is desired to fire a large number of rounds with great rapidity, an auxiliary storage reservoir is used, into which the air is compressed ordinarily to twice the pressure to be used in the gun. After each discharge the



EIGHT-INCH PNEUMATIC TORPEDO GUN.

air is drawn from these, to restore the pressure in the firing reservoir to any desired point.

THE COMPRESSORS.

The air compressors may be of any type capable of giving the high pressures to be used. We have used the compressors of the Norwalk Iron Company. These compressors perform the compression in two stages, there being an intermediate cooling in passing from the first compression to the last.

Where cooling processes are to be used for other purposes on shipboard, the air compressors can be utilized. They may also be of use where the pneumatic gun-carriage system is introduced.

THE SHELL.

The shell is made at present of brass tubing and castings, made as light as consistent with the necessary strength for handling and in being fired. The shell is retained in its proper trajectory by means of the tail tube, to which are attached spiral vanes. It is centered in its passage through the bore and kept from metallic contact with the same by means of non-metallic pins in the head, the leather gas check at the rear end of the cylindrical part of the body, and by the vulcanized fiber projections riveted to the spiral vanes of the tail.

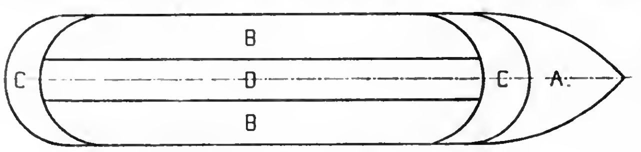
We have recently succeeded in making the conical point and cylindrical portion of the shell of a single seamless piece, it being produced by hydraulic pressure. This was not considered easy of accomplishment in view of the fact that, for the 15-in. shell, the piece is 14$\frac{3}{4}$ in. outside diameter, 80 in. in length, and $\frac{1}{8}$ in. thick. The conical point is made strong enough to resist crushing from impact with water, but so thin as to readily crush when striking a solid target.

THE CHARGE.

The charge used thus far has been uncamphorated explosive gelatine, having a core of dynamite. This core is for the purpose of producing a complete detonation of the less sensitive explosive gelatine. I would prefer, for this purpose, compressed dry gun-cotton, as cold weather does not affect its properties as a detonating substance. The arrangement of the charge is essentially as shown in the diagram.

At the front and rear of the charge, I would use camphorated gelatine to increase the chances against explosion by shock both in starting the shell and in striking the target. For this purpose also a diaphragm is placed so as to stop off the charge some distance from the point; this will give time for detonation of the charge from the *rear end* before the front can be exploded by shock. To guard still further against the possibility of explosion by the impact and give time for the electrical primer to act, it may be necessary to place a cushion of felt or other elastic substance in front of the diaphragm. This can only be determined by actual experiment against armor plates.

The small engraving herewith shows the arrangement of the charge; *A* is the empty space at point; *B B* uncam-



ARRANGEMENT OF CHARGE FOR DYNAMITE GUN.

phorated gelatine; *C C* camphorated gelatine, and *D* the gun-cotton or dynamite core.

I have preferred uncamphorated explosive gelatine because it gives the maximum explosive energy for specified volume of shell, both on account of its very great energy and its high specific gravity. The energy compared to dynamite No. 1 is as 142 is to 100, according to General Abbot and other authorities. Its specific gravity is 1.6 compared to 1.2 of dynamite No. 1 and 1.0 of gun-cotton. Thus, in a given volume of shell the explosive energy, where uncamphorated explosive gelatine is used, will be as 189 is to 100 when compared with the same volume of dynamite; compared with dry gun-cotton, it would be 263 to 100, or close on to 2$\frac{5}{8}$ times the explosive energy. If *wet* gun-cotton is to be used there is a strong probability of the relative strength being greater. I am aware that there is some question as to the relative strength of gun-cotton as given by General Abbot, but it is seen that a large margin is likely to remain in favor of the explosive gelatine.

It will undoubtedly rest with each branch of the service to select that explosive which seems to it safest and best. I merely mention my own reasons for having selected and used uncamphorated explosive gelatine. I have used this for more than two years, during which time I have fired more than one ton of gelatine made at the Nobel's Explosives Company's works near Glasgow. Besides use in the gun I have subjected it to various tests of alternations of heat and cold, as well as subjecting it to very severe shocks. I am satisfied from this experience that, if well made, it is not subject to deterioration while in store, or to explosion by shock if handled as carefully as gunpowder.

The only unfavorable thing that I have observed, and that but rarely, is a very minute exudation of nitro-glycerine when thawed after freezing. I propose to meet this contingency by having the cartridges made up in disks having a central hole for the detonating disk of gun-cotton. These large disks are to be covered completely by a rather thick covering of asbestos paper or other absorbent material, having incorporated therewith an alkaline substance, such as carbonate of magnesia, so that any exudations of nitro-glycerine will be absorbed by the covering, and any free acid which might be present or develop in the exuded nitro-glycerine will be neutralized. Besides this, the thick non-conducting envelope will partly protect the explosive from great alternations of heat and cold.

In view of the advantages of the explosive gelatine and the improvements made in its manufacture, it will be well to make thorough tests therewith before definitely settling upon the exclusive use of gun-cotton. While reliable explosive gelatine has thus far only been procurable from abroad, at least two of our reputable and experienced manufacturers of high explosives are prepared to manufacture the gelatine under the Nobel patents and processes.

THE FUSE.

The earliest experiments with the pneumatic gun demonstrated that the ordinary fuse arrangements were insufficient to obtain the best results with high explosives.

It was found necessary to produce the initial explosion at the *rear* end of the charge, to produce the maximum effect on a solid target.* It was important, therefore, that this explosion should take place an instant *before* full impact.

To obtain the very important torpedo effect which is the primary object of the pneumatic torpedo shell, it was necessary to cause the explosion to take place an interval of time *after* striking the water. The tamping due to the submersion would give the maximum energy of the charge, and this against the more vulnerable under-water hull. Where counter-mining was to be attempted against ground mines, it was desirable to ensure some of the shells getting to or near the bottom before exploding. Above all, the fuse must be assuredly safe in storage and in handling. Consideration of these requirements has led to the development of the electrical fuse.

This consists of four parts:

1. The electrical battery;
2. The low-tension primer;
3. The circuit breaker; and
4. The detonating cap.

The chloride of silver battery has been selected as being most suitable. Although the electro-motive force is low, the internal resistance of the battery, as made, is very low, and a small single element suffices to bring the bridge to a red heat. But to ensure against accidental increase of

* I fired a shell charged with sand only against a target of thin iron plates, and three were perforated. A shell charged with dynamite arranged so as to explode by impact from the front end was next fired, and only one plate was perforated. A shell charged as before, but arranged so as to explode from the rear end, was fired and six plates were perforated, that being all that constituted the target. Commander Folger's experiment also indicated the necessity of having the initial explosion at the rear end of the charge.

resistance in the circuits and to reduce the *time* required to fire the primer, one set of batteries is made quadruple, the other two are double.

Each set is arranged in series. All of the elements of the quadruple battery, which is in the rear end of the shell, are wet with salt water before insertion into the shell. One pole of this battery is connected, through the primer embedded in the fulminate of mercury detonator, to the metallic body of the shell; the other pole is connected with a light copper cone fixed in the conical point of the shell and insulated therefrom. The shell striking any solid target, either normally or otherwise, will cause the outer shell to crush in on the insulated cone, close the wet battery circuit and explode the charge.

The double dry battery is placed in the point and another at the rear end. This last is inserted as a matter of precaution rather than as an absolute necessity. One element of each of these double dry batteries is wet up, and is ready for action as soon as the salt water enters the other element. Upon the shell entering the water, the dry element becomes wet, the current then passes through a primer which ignites a time train. This in turn ignites the detonator. The time train is adjustable so that a variable submersion before explosion can be obtained. The rear dry battery acts in the same manner should the other fail. If it is desired to cause the shell to reach the bottom before exploding, a water cap is attached to the dry battery in the point of the shell. Provisions are made to protect the front and rear batteries from moisture until the shell has left the bore of the gun. If fighting in fresh water, a small bag of salt is placed in the dry battery fuse case.

The circuit-breaking device ensures all circuits being retained open until the shell has left the bore of the gun. If anything should be amiss with the circuits, no explosion will result until the shell is some distance beyond the muzzle. Nothing can be amiss, however, if proper care is taken in making up the shell, arranging the circuits, and testing. The circuits can be tested at any time before inserting either the batteries, primers, or detonators; there need be no guess-work as to the condition of the circuits at any time. The batteries, primers, and detonators need not be inserted until just before using. A double set of circuit breakers, primers, and detonators are used to increase certainty of action.

To guard against the chances of breaking the very fine filament of platinum wire constituting the wire bridge, it is embedded in a very solid cake of compressed gunpowder. . . . .

RIFLING.

To the professional mind it naturally occurs that it would be well to resort to rifling, dispensing with the long and cumbersome tail. To rifle a projectile so long and so low in density as the one in use would involve an exceedingly rapid twist. According to Professor Greenhill's formula, a twist of 1 in 13 is required for a cast-iron shell 8 calibers in length. This will be about the average length of the dynamite shell without the tail; it being, however, somewhat shorter in the larger calibers. The density of the charged shell will be much less than that of the common iron shell; hence it is probable that a twist of about 1 in 11 will be required. To impart so sharp a twist will put a very considerable torsional strain on the thin wall of the shell, as also on the (proportionately) equally thin walls of the gun. Again, the explosive will have to sustain an additional shock due to the very high angular velocity imparted to the shell. There is very great danger from the heat which will be generated in the friction of the projectile while being forced through the gun bore.

While, as an artillerist, my natural predilections were for rifling, consideration of the foregoing facts led me to make haste slowly in this direction. I had constantly before me the experience gained at the proving ground at Sandy Hook and in foreign services, where the usual result of the experiments of firing the high explosives from rifled powder guns was a final dissolution of the gun.

Consideration of the matter has led me to see a number of ways by which some of the difficulties I mentioned may possibly be overcome. I have now a 2-in. rifle gun in which I shall test the matter even to the final bursting of the gun, establishing by my experiments, if possible, the limits to which the rifle can be used with safety.

USE OF GUNPOWDER FOR PROPULSION.

The feasibility of using gunpowder for the propulsion of shell charged with high explosives is continually broached. It has been frequently tried, but invariably with final disastrous results where the experiments have been carried up to moderately large charges. By large charges I refer to shell charges of not less than 50 lbs. and reaching up to 1,000 lbs., and even to shell charged with a ton of high explosive.

The advocates, or rather the predictors, of the use of high explosives from powder guns also demand penetration before explosion.

If large charges are to be thrown, the shell must necessarily be made thinner, and it is very doubtful if it will then withstand the concentrated blow it receives upon striking the target so as to penetrate even a moderate thickness of armor. The battering shell of the 100-ton gun contains a bursting charge of only 25 lbs. of gunpowder. It would seem that the walls of the shell would have been made as thin as consistent with ability to perforate armor without breaking up.

Assuming that 25 lbs. of a high explosive could be substituted for the gunpowder, it is very doubtful if it could be carried through heavy armor successfully before explosion. There is no record of large battering shell fully charged with gunpowder having perforated armor over 6 in. in thickness, without explosion until after perforation. On the contrary, explosion takes place prematurely, almost immediately upon impact, with the result of less injury to the target than that produced by an uncharged shell.

Much more surely will this be the case if a high explosive be substituted for the gunpowder as the bursting charge, unless the shell cavity is well cushioned. To do this involves reduction of explosive capacity. The energy available, after breaking up the very thick and tough walls of steel shell, will be but little greater than that produced by the gunpowder. The effect as to material injury or man-killing power will not much exceed that producible by the shell charged with gunpowder.

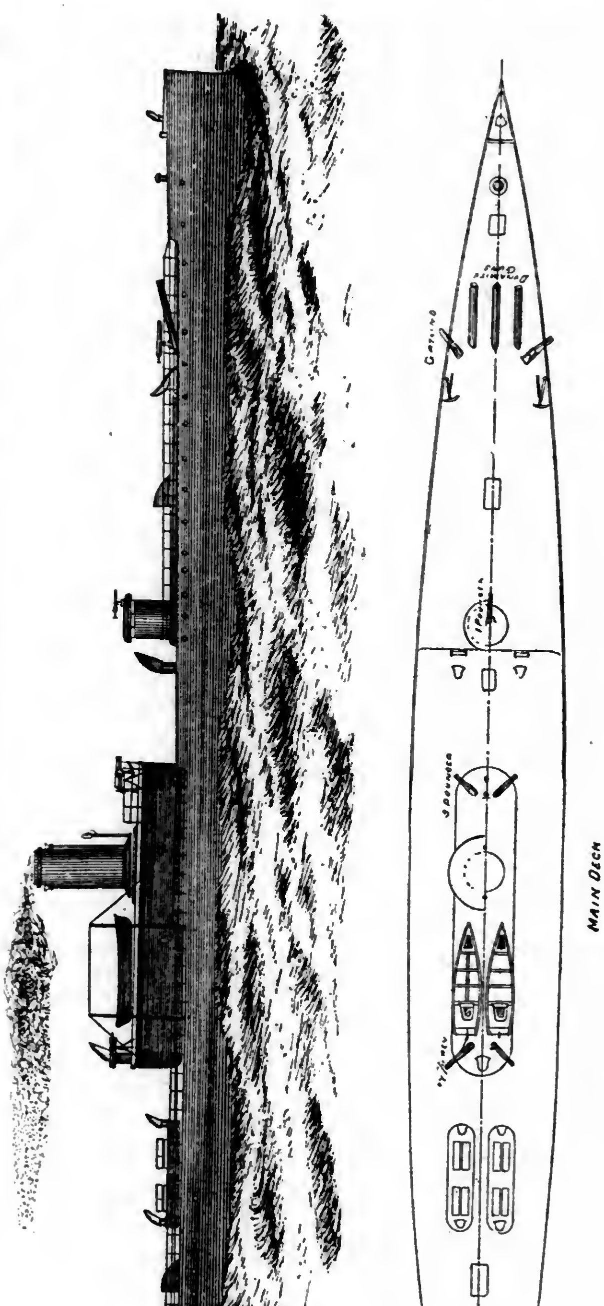
In firing a shell from a powder gun, the walls of the shell must necessarily be sufficiently strong to withstand the initial shock. This limits somewhat the capacity for bursting charge, even where armor piercing is not sought for. If a high explosive is used, some cushioning device is requisite, and a further reduction of capacity ensues.

Assuming that a shell charged with some of the high explosives can be thrown with safety from a powder gun under normal conditions of pressure, it is known that abnormal pressures, varying therefrom as much as from 5,000 to 12,000 lbs. per square inch, are not infrequent. This may be looked for especially when the gun is warmed by continuous firing. In addition to this, the shell and the contained charges may become warmed by remaining in the hot gun bore some little time before being fired. The high explosives increase very rapidly in sensitiveness by slight increments of heat. If, then, with this condition of increased sensitiveness we have in addition an abnormal pressure, a premature explosion is very likely to occur.

In rapid firing of powder guns, when shell or shrapnel charged with powder are used, premature explosions of the shell are not infrequent. Much more will this be the case when the bursting charge is one of the high explosives.

In this connection another matter is to be considered. It is well known that the high explosives are capable of producing more or less violent explosions, depending upon the character of the initial shock or detonation. The more insensitive the explosive, the more powerful must be the detonating charge, to produce an explosion of the first order. Fulminate of mercury appears to be requisite in all cases. But fulminate of mercury is even more sensitive to shock than either ordinary dynamite or dry gun-cotton, hence the resulting shock must be tempered so as not to explode the more sensitive *detonating* charge rather than the specially insensitive *bursting* charge. Wet gun-cotton has been substituted for powder charges, but being quite

wet reduces its explosive ability nearly to a par with gunpowder. Particularly is this the case where no detonating charge of dry gun-cotton and fulminate of mercury is used. Where the explosion takes place by simple impact,



DYNAMITE GUN CRUISER, UNITED STATES NAVY.

not alone is it of a low order, but as the initial point of explosion is from the front, the resulting injury to the target is less than from a blank shell. This was exemplified in some experiments made at the Naval Proving Ground by Commander Folger, U. S. N. . . . .

THE DYNAMITE GUN CRUISER.

This vessel, now building for the United States, will have three guns of 15-in. caliber. These are placed abreast and parallel at a fixed angle of 16°, the muzzles projecting through the deck at about 37 ft. from the bow. The range of these guns will be at least one mile. The full caliber shell will carry 600 lbs. explosive gelatine, equivalent to 852 lbs. of dynamite No. 1 or to 943 lbs. of gun cotton. Shell containing smaller charges can also be thrown by the system of sub-caliber recently developed. The speed will be at least 20 knots.

The speed of 20 knots is exceeded by the small and very light torpedo boats built abroad, but the hull of this vessel will be sufficiently strong to be serviceable in rough water, which is not the case with the more lightly built torpedo boats. The training of the gun is given by steering the vessel. The range will be varied by the valve arrangement previously referred to.

The vessel has twin screws and steam steering gear. The arrangements will be such that the guns can be fired from the conning tower. The shell are handled by hydraulic machinery throughout the loading, so there is no danger in the manipulation in a sea-way. The guns can be loaded two times per minute; 30 full caliber shell can be carried.

It will be seen that this vessel is likely to be very well under control and will probably prove itself a formidable auxiliary war vessel.

The general dimensions of this vessel are: Length over all, 252 ft. 4 in.; beam, 26 ft. 5 in.; mean draft, 9 ft.; displacement, 725 tons. The motive power is furnished by two triple-expansion engines, developing about 3,200 I.H.P. The armament, besides the three 15-in. pneumatic torpedo guns, will include two 3-pounder and one 1-pounder rifle, two 37-mm. revolving cannon, and two Gatling guns.

CONCLUSION.

Owing to the unknown character of the pneumatic gun, its possibilities are not generally recognized, and many professional men have been loth to accept it as a practical appliance of war. It is considered by many as a species of quack medicine, as a toy—a pop-gun. I have therefore been constrained to argue the case in laying before you my views as to its applicability to naval uses, basing my arguments chiefly on accomplished facts.

I have pushed this work on as vigorously as I could, because, aside from the professional interest involved, I saw in it possibilities of usefulness in cases of public emergencies which may arise even now, before a regular modern armament could be provided.

While I have never considered it as all-sufficient for defensive purposes, I have thought it a very valuable auxiliary in any event. But most of all, if attacked before modern guns, ships, and forts are provided, we could at least very seriously injure any attacking force before being ourselves destroyed. Our sting will be felt, and an attack will not be made with absolute impunity. The power that we have to inflict *some* injury will not be without weight in considering the advisability of attacking us.

No small element in considering the effectiveness of this weapon will doubtless be the moral effect. The knowledge that escape is not assured when the enemy's missile has failed to make a direct hit, and that the danger may even be *enhanced* by that miss, will not have a reassuring effect on the crew of the vessel attacked.

Absolute infallibility of successful action with each missile from this weapon can no more be assured than with those from the best of modern powder guns under the most favorable circumstances. As I have before said, skill and nerve on the part of the manipulator is as requisite with this as with other war appliances. It is for this that we require highly trained and skillful naval officers. But we have seen that the *probabilities* of attaining desired results are certainly greater than with any other torpedo appliance.

In making an attack of any kind, reliance is not usually put upon the probability of producing successful results with a single shot or torpedo. The chances are increased

by increasing the number of guns used or torpedoes projected. For a given weight to be carried, or for a given amount to be expended (looking at it simply from a commercial point of view), a very much larger number of torpedoes of the pneumatic gun type can be utilized than of any other having any approach to relative effectiveness.

FURNACES FOR BURNING LIQUID FUEL.

(*Continued from page* 167.)

WE continue below the summary of Herr Busley's article on this subject, which was begun in our last number. For the cuts given with these articles we are indebted to the London *Engineer*.

III.—SPRAY FIRES.

This class includes all the later plans for burning liquid fuel. In them the oil is divided into small sprays by a steam and air jet, and is then nearly completely burned up in a vaporous condition by means of the introduction of air. This air is generally introduced by the draft caused by the jet, and the oil is supplied from a tank above; in the case of ships, however, it is pumped up from the hold below. The combustion is so perfect that scarcely any smoke is generated. The temperature attained by these fires is so high that it is usually found necessary to protect the sides of the fire-boxes by fire-brick coverings, or else to divert the direct flame from them. In spray fires the oil is divided into minute sprays by means of sprinklers, and they may be divided, with reference to the construction of these sprinklers, into: 1. Slit Sprinklers. 2. Pipe Sprinklers. 3. Nozzle Sprinklers.

1. The *Slit Sprinkler* which is first on the list, is that of Lenz, shown in fig. 9, which was introduced in 1870 on steamers employed on the Volga and the Caspian Sea. Two pipes lead to the sprinkler in the fire-door. The upper pipe introduces the oil, the lower one the steam. The sprinkler is of cast brass, and divided in two halves by a partition, *A*, so as to prevent the intermixture of the oil and steam. The partition terminates in front in a tapering tongue, *B*, in the filed grooves of which the oil flows out to be blown away in separate thin sprays by the steam that streams out from underneath this tongue. The intervals between the sprays of oil serve to facilitate the access of air. The flow of oil and steam is regulated by the circular slides *C C*, which are pressed by spiral springs against the inner walls of the cylindrical sprinkler. A spigot fastened eccentrically in the axle of the spindle *D* grasps each slide. The spindles *D* are firmly packed at *E* against the partition and terminate outside the sprinkler with a square section, so that they can be turned by keys, and can thus effect the displacement of the slides. Should the flow of the oil-residue be stopped up the oil-pipe is shut off, and the tap *F* is opened, and the tongue-openings are then blown through. When a thorough cleaning is necessary, the cover *G* is unscrewed. With this device the trouble was that the fire-box was not uniformly heated, and combustion was therefore imperfect. The flame was kept too much together, and soon destroyed the walls and the ends of the pipes.

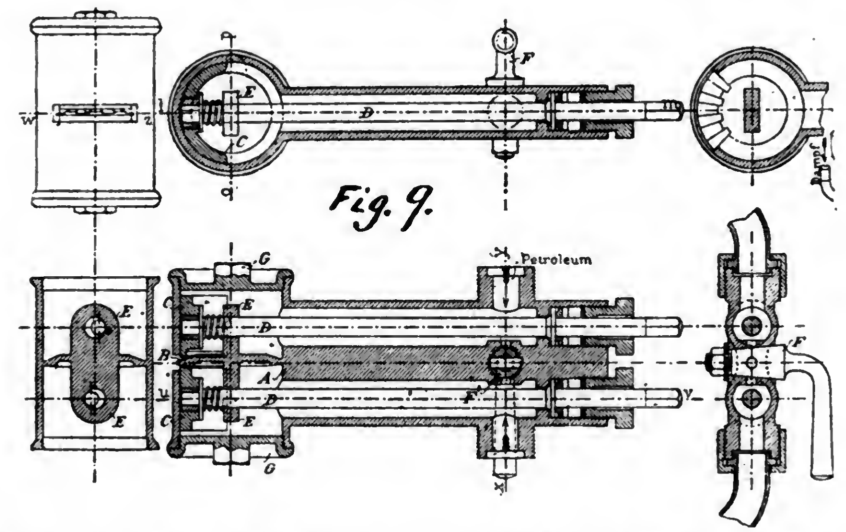


Fig. 9.

To obviate these difficulties, Lenz introduced a new form, shown in fig. 10. In this there is a circular opening round the cylindrical chamber instead of a straight slit. The

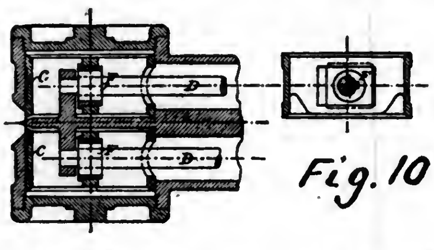


Fig. 10

slides *C C* are also made cylindrical, and are movable in the chamber. The tongue was also altered so as to obtain a broader flame, but the arrangement of the rest of the sprinkler remained the same. This modification worked much better than the first plan.

The slit sprinkler of Körting (fig. 11) was made in 1872, and worked with air, which was compressed in a specially constructed steam jet apparatus. The compressed air was conducted into the sprinkler by means of tubing and was divided by a partition into two flat currents, above and below which the slits for the oil were placed. The cut

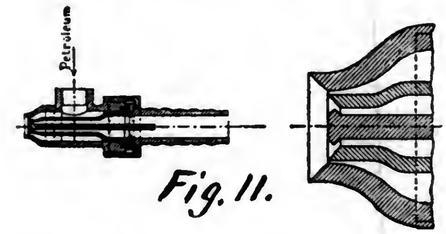


Fig. 11.

shows separately the mouth of the sprinkler, full size; it will be seen that the slits are very narrow, and in practice they were frequently stopped up. The sprinkler could not be cleaned without being taken completely to pieces, which entailed considerable delay, for which reason Körting abandoned it finally for another plan.

The slit sprinkler of Artemev, introduced in 1878, was simpler than that of Lenz; it is shown in fig. 12. The steam and oil are conducted in separate pipes to the semi-circular slit, the tongue of which is formed by a disk sharpened at its edge; this disk is held in place by a single bolt. The sprinkler is bolted to the boiler by the castings *A A*, in which it can revolve. It is also provided with a blow-cock, *B*, and can be taken apart and cleaned in a very short time.

The slit sprinkler of Karapetov, which was used espe-

cially in locomotives, is shown in fig. 13. It consists of a central body with three channels, the upper one conducting oil, the central one air, and the lower one steam. The

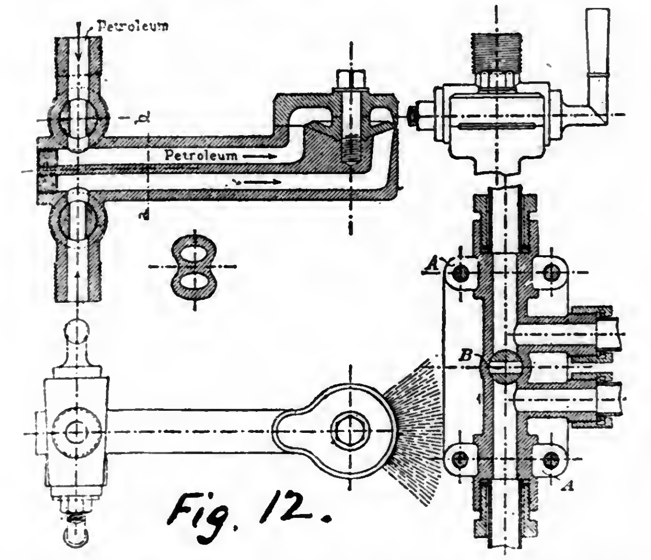


Fig. 12.

steam jet draws the air through the central channel and brings it to bear on the drops of oil to be consumed. The supply of oil is regulated by a slide and hand-wheel; the

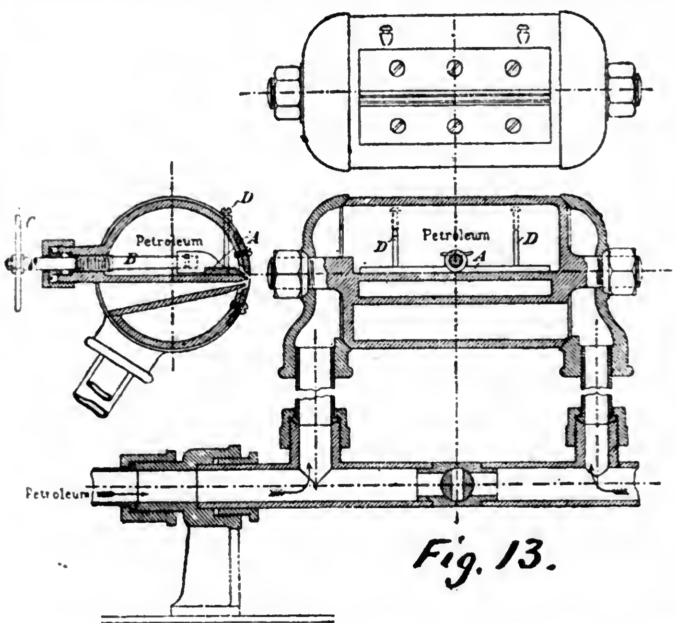


Fig. 13.

steam by a valve. By this sprinkler the jet of burning oil is thrown down against a fire-brick floor in the fire-box, and does not strike the iron plates directly.

In Brandt's sprinkler (fig. 14) the oil is brought through a central pipe and passes into the large part, *A*, of the exit chamber, which is divided into two parts, steam being introduced into the smaller section of the chamber. The oil flows through the openings *C C* into the compartments *F F*, formed by the ribs *E E*, and is thrown out in small streams through the openings *G G*. It was claimed for this device that it filled the fire-box with flame, as shown in fig. 15, insuring even heating. The chief objection to it was the difficulty of getting at it when it was clogged or needed repairs. It was impossible to reach it until the boiler was cooled down.

Jensen's slit sprinkler was tried in 1883 with some success. It is shown in fig. 16, but was afterward slightly modified, making the steam and oil jets meet at an angle of 45°, instead of issuing in parallel lines, as shown.

Herr Busley thinks that slit sprinklers entail so much waste of oil that their use is only possible in oil regions where the fuel costs little or nothing. For marine boilers there is also the drawback that for the water jets or sprays fresh water must be used. The great disadvantage, however, is the constant tendency of the slits or openings to clog and stop up. It also sometimes happens that a sudden draft will blow out the flame, and this causes an ac-

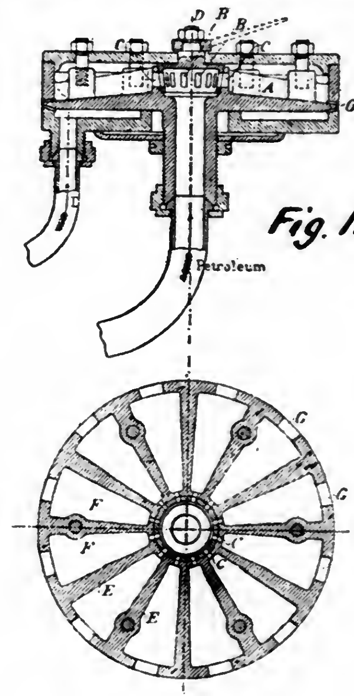


Fig. 14.

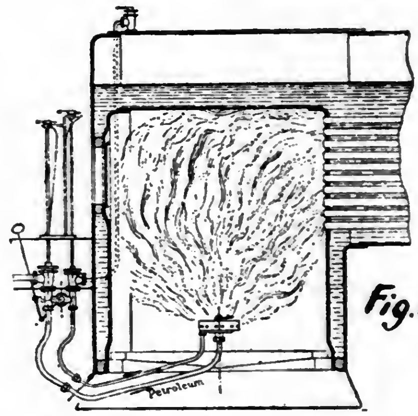


Fig. 15.

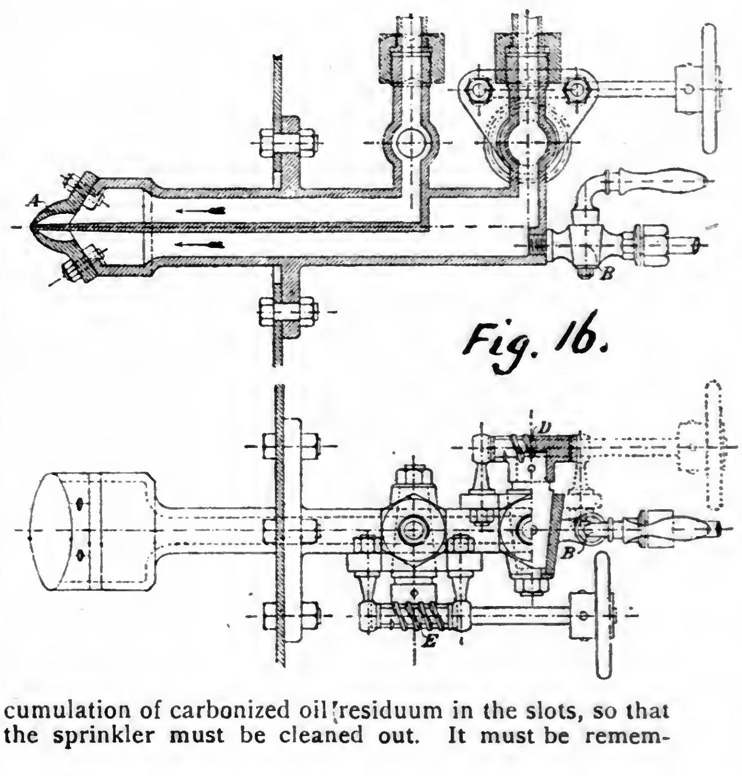


Fig. 16.

cumulation of carbonized oil residuum in the slots, so that the sprinkler must be cleaned out. It must be remem-

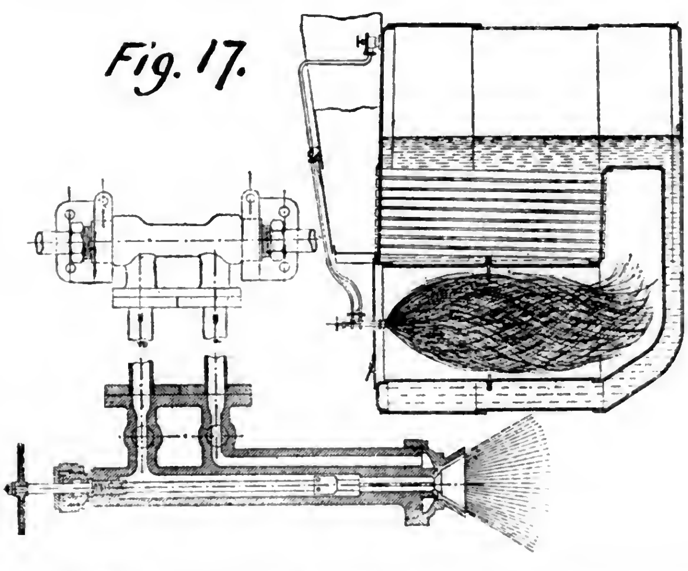
bered also that in these cases the abrupt stoppage of the fire causes sudden cooling of the plates, which is very injurious.

2. *Pipe Sprinklers* were first used by Mr. Brydges Adams in America, in 1863, on locomotives. In his arrangement an air-tight oil tank was placed near the boiler, and the pressure pipe of an air-pump was introduced through the cover of this tank. Two concentric pipes led from the tank to the fire-box; the inner pipe reached down to the bottom of the tank, while the outer one opened into the air space above the oil. The pressure from the air-pump forced a continuous stream of oil into the pipe, which was surrounded by a current of air in the outer pipe, this current serving to spray the oil and insure its combustion. This system worked well, but was found too complicated for a locomotive.

Bullard's system, more recently introduced, is a modification and improvement of the Adams plan. In this there is an oil and air tank on each side of the fire-box, with which any desired number of burners in the fire box communicate. The fire-box can be used for coal when preferred. The air is compressed by a Westinghouse pump. A noteworthy improvement of Bullard's is the simple and practical pressure-regulator for the air. The air as it enters presses against a valve, which is kept down by a spiral spring. If the air pressure be too great the valve is lifted; at the top of the piston-rod of the valve a toothed rod is fastened which turns a toothed sector on the axle of the steam regulator tap, so that the supply of steam to the steam cylinder of the pump is lessened. The pump now works more slowly until the normal pressure is again reached, and the spring presses the valve down into its old place. The supply of oil is regulated by a ball valve. The flame of each burner can be reduced or enlarged by means of a hand-wheel, which brings the oil pipe nearer or takes it farther away, as desired. In the former case the supply of oil is increased and that of air decreased; in the latter the converse is the case. A great advantage claimed by this system is that the sprinklers are said not to get heated, and it is further stated that they do not get stopped up with oil residue.

Brandt's pipe sprinkler, shown in fig. 17, was introduced in 1880, principally for marine engines. The steam and

Fig. 17.

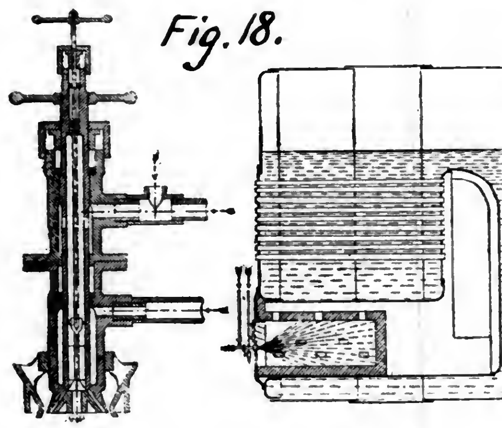


oil pipes are united in a brass casing; their supplies are regulated by cocks. The oil escapes through a circular orifice which is regulated by a hand-wheel and spindle and a needle. The steam escapes through another orifice surrounding the former. The oil and steam mix in the space between the needle and the cap, which is regulated by a screw in the brass casing, and enter the fire-box in a conical bundle of streams, which are then burned up. The cocks in the oil and steam pipes are left open during work, and the supply is regulated entirely by the needle. The sprinkler is so constructed that it can be turned out of the fire-box, the cap can be removed, and the entire apparatus thoroughly cleaned. The requisite air enters through holes in the door and the ash valve in the fire-box. This sprinkler is preferable to slit sprinklers, inasmuch as it heats the fire-box more evenly, and entails a smaller, though still extremely high, consumption of oil.

The pipe sprinkler of Nobel is an improvement on that of Brandt, as, by means of a spirally grooved cylinder in the sprinkler, a spiral movement is given to the oil and steam spray, and thus the fire-box is more evenly and thoroughly heated, and the radiation is improved, as well as the combustion. A steam boiler on this system at the Moscow Industrial Exhibition of 1883 is said by Garlishambarw to have generated as much steam with from 50 to 60 lbs. of oil residue as could have been generated under the same circumstances by 100 lbs. of coal. This statement, however, agrees doubtless with the reputed fact that from 2 0 to 2.8 kilogs. of oil residue were required for each indicated horse-power per hour, and compels the conclusion that the boiler and engine must have been exceptionally efficient.

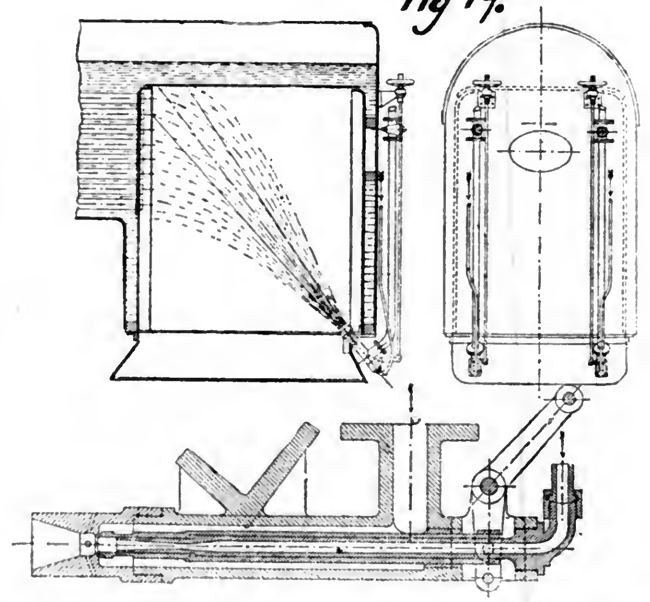
Smith's pipe sprinkler, recently patented in England, and shown in fig. 18, consists of two concentric pipes, of which the inner one can be displaced against the outer one, and of a central screw spindle with a cone-shaped outlet. The outer pipe receives the oil from a supply pipe, which has a branch pipe for the admission of air. The oil and

Fig. 18.



air enter the inner pipe through openings in its circumference and reach the cone outlet. The space between the outer and inner pipes is filled by steam, which streams out of the cone-shaped outlet in a circular form. The inner pipe has a valve at its outlet leading to the cone, and

Fig 19.



leaves circular slits for the escape of the oil and air as the central spindle keeps turning. In a similar manner the expansion of the inner pipe and the contraction of the outer pipe act like a cone-valve when the inner pipe is displaced

by means of a hand-wheel, and the escape of steam is thus regulated. A hollow cone is screwed over the outlet, which enables the air to be sucked up while the spindle is at work, and which can be displaced as required. The great objection to this arrangement is the complication of the apparatus.

In the pipe sprinkler of Korting, shown in fig. 19, steam was carried through the inner pipe, while the oil is fed through the outer pipe. The supply of steam was regulated by a lever and hand-wheel, by which the opening at the nozzle could be increased or decreased, and the supply of oil was regulated in the same way. The oil and steam spray as it leaves the pipe sucks in air through holes in the side of the outflow cone, thus increasing combustion on the surface of the oil. Air was also admitted through the ash-pan. In a locomotive boiler the flame was directed upward, as shown in the cut; this was found to injure the crown-sheet and tube-plate. In marine boilers the flame was thrown back on the fire-brick bridge. This sprinkler had the merit of simplicity in construction, and it could also be easily cleaned.

Pipe sprinklers in use have proved themselves more economical than slit sprinklers, and they also use less steam. They are, like slit sprinklers, subject to being stopped up by residuum and impurities, but they can generally be cleaned with less difficulty. In most cases the mouthpieces can be removed and thus cleaned with very little delay. The main advantage of the pipe sprinkler consists in the fact that the flame is generally spherical, and thus, in marine boilers, fills up the cylindrical fire-box better, and heats it more equally than the flame from a slit sprinkler. This also saves the walls of the fire-box and makes the use of additional fire-brick walls unnecessary. This effects some saving.

Both pipe and slit sprinklers, however, have generally given way to the nozzle sprinklers, which form the last and largest class to be described.

(TO BE CONTINUED.)

A SWEDISH FAST PASSENGER LOCOMOTIVE.

(Translated from the *Revue Generale des Chemins de Fer.*)

THE management of the Swedish State Railroads operated in 1886 a total of 2,469 kilometers of railroad of standard gauge (4 ft. $8\frac{1}{2}$ in.), in the train service of which there were employed 334 locomotives, including 146 passenger engines; 149 freight engines with separate tender, and 39 tank engines employed in freight and switching service.

In the recent construction of locomotives for these lines, under the direction of Mr. Almgren, several new devices, which are of interest, have been introduced.

These innovations have been for the most part used in the building of locomotives for the fast passenger trains, a new type of which has been introduced. Seven of these locomotives were completed at the shops at Trollhattan in 1886, and have since been in service, and 10 more are now under construction at the same place.

These locomotives are the heaviest passenger engines ever put in service on the Swedish lines; they have cylinders $16\frac{1}{2}$ in. in diameter, and 22-in. stroke, four coupled drivers 74 in. in diameter, and a truck of the Bissell pattern with four wheels 43 in. in diameter. The accompanying illustrations show a longitudinal section, a plan, and four half cross-sections of the engine, and the general construction and arrangement can readily be seen from them. The dimensions of the boiler and fire-box are given in the table below:

DIMENSIONS OF BOILER:

	Ft.	In.
Length of barrel	12	$9\frac{1}{2}$
Diameter of barrel	3	$10\frac{3}{4}$
Thickness of plates of barrel	0	$0\frac{1}{2}$
" smoke-box tube-plate	0	$0\frac{13}{16}$
Seams, double-riveted, lap	0	$3\frac{1}{2}$
Space between rivets, centers	0	3
Diameter of rivets	0	$0\frac{3}{4}$
Outside fire-box plates, thickness	0	$0\frac{9}{16}$
Distance between stay-bolts, centers	0	4
Diameter of stay-bolts	0	1
Material of boiler shell, iron.		

FIRE-BOX:

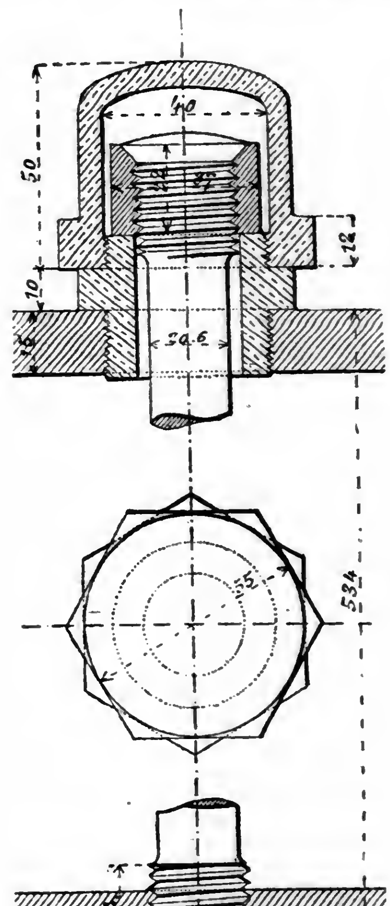
	Ft.	In.
Length, inside, at bottom	7	$0\frac{1}{2}$
Width "	3	$0\frac{1}{8}$
Height at front end	5	$1\frac{1}{4}$
" rear end	2	$10\frac{7}{8}$
Thickness of side-sheets	0	$0\frac{9}{16}$
" crown sheet	0	$0\frac{3}{4}$
" tube-sheet	0	$1\frac{1}{8}$
Material of fire-box, copper.		
Number of tubes, 130; material, iron.		
Outside diameter of tubes	0	2
Length	13	$3\frac{1}{2}$

Grate surface	22.61	sq. ft.
Heating surface: Firebox	85.04	"
" " Tubes	891.28	"
Total	976.32	"

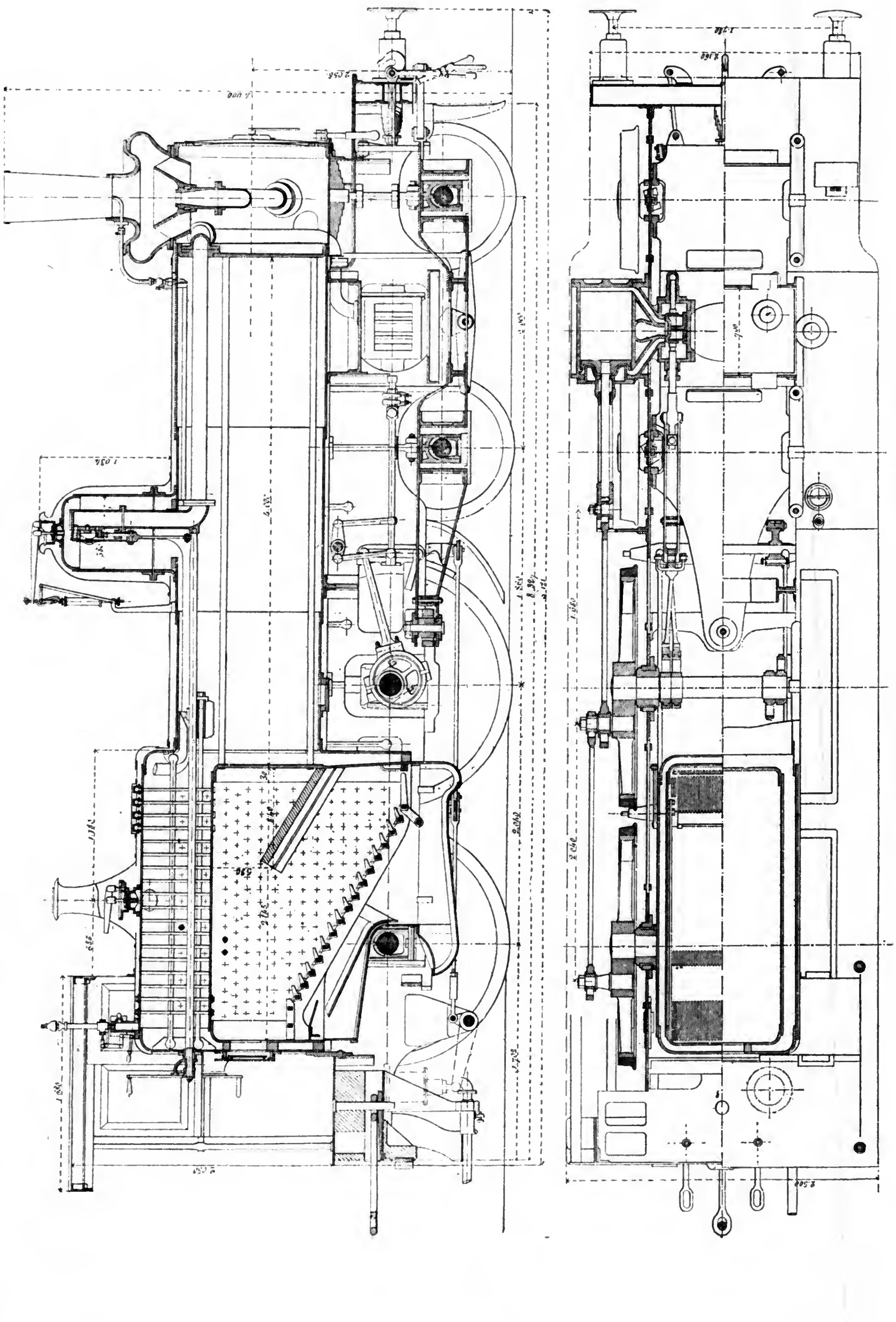
(The dimensions given in the cut are in meters and millimeters).

The arrangement of the plates of the boiler barrel is telescopic, the largest plate being next the fire-box end.

The fire-box is provided with a brick arch, resting at the ends on brackets riveted to the side plates. The crown-sheet of the fire-box is joined to the outer crown-sheet by long stay-bolts of iron of the ordinary form, except that



STAY-BOLTS, YARROW SYSTEM.



FAST PASSENGER LOCOMOTIVE, SWEDISH STATE RAILROADS.

(Dimensions in Meters and Millimeters.)

four rows at the front end of the fire-box are stay-bolts of the Yarrow system. These stay-bolts, as shown in the accompanying cut, are fastened at one end in the fire-box crown-sheet and at the other end are allowed to work freely through a hollow plug screwed into the outer sheet. The end of the stay-bolt is riveted on a washer which bears upon the upper end of this plug; the latter has a screw thread upon it, upon which is screwed a cap which prevents any escape of steam. It is claimed for these stay-bolts that a certain amount of motion is allowed which prevents the stripping of the thread and diminishes the strain which the expansion and contraction of the fire-box imposes on stay-bolts of the ordinary pattern.

The grate of the fire-box is composed of 15 iron bars resting on brackets, these brackets forming a sort of staircase inclined at an angle of 28°. The bars are furnished with a series of projections (somewhat like the shaking grates used in this country), those on each bar extending over the bar below, as is shown in the cut.

In this way a grate has been made in steps, of a form which favors the abundant passage of air, which is indispensable in order to burn completely the Swedish coal. This coal is mined from a comparatively recent geological formation, and contains 20 per cent. of cinder. The mixture actually burned in these fire-boxes is composed of English and Swedish coal, in equal parts, but it is expected that the proportion of Swedish coal will be gradually increased until it is four-fifths of the whole.

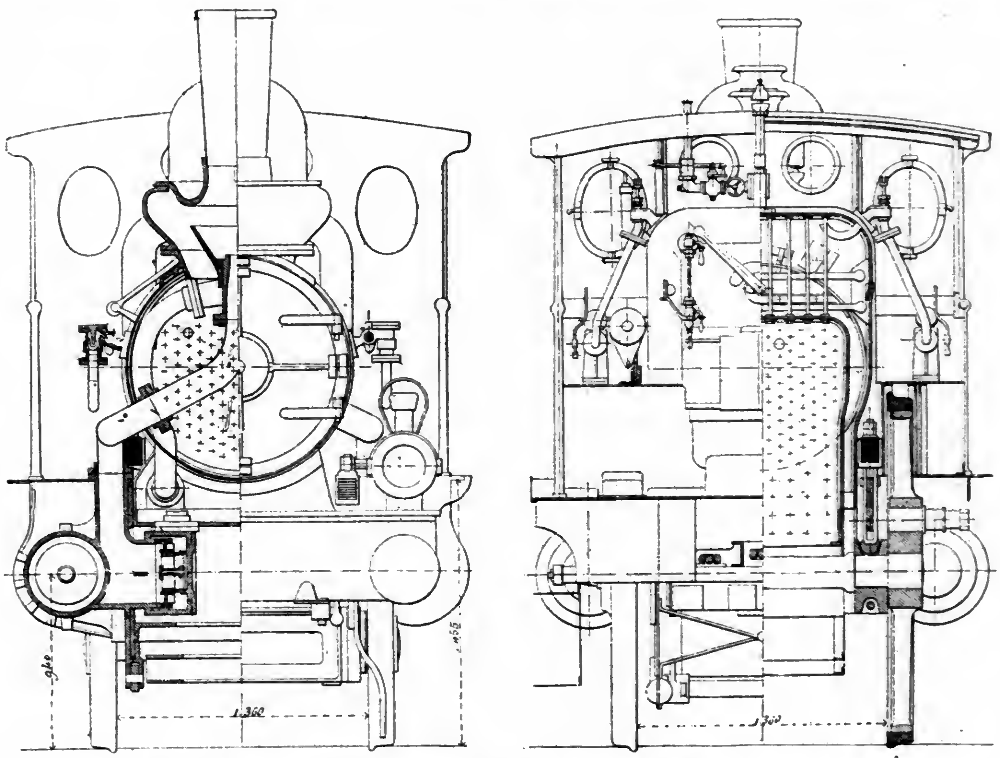
At the foot of this inclined grate, at the forward end of the fire-box, is a plate composed of bars or fingers carried upon an iron bar across the fire-box, which serves the same purpose as the dead plate or dump grate frequently used in our own engines burning bituminous coal. In front of this and against the forward part of the fire-box is placed a single bar with numerous openings, insuring an abundant supply of air in that portion of the fire-box.

The ash-pan is very large, and is made of the form shown to permit the placing of the rear driving axle under the fire-box. A double plate with air spaces is used to protect the axle from the heat.

The tubes are of iron. Before putting them in place their ends are slowly heated to a red heat, and then cooled off in slaked lime, which renders them ductile. The end which enters the fire-box tube-plate is then drawn down from 50 to 47 millimeters in diameter. The hole in the tube-plate is made 48 millimeters in diameter; the tube when in place is brought into perfect contact with the plate by an expander, and is then riveted over and a ferrule put in. At the smoke-box end the tube is left at its original diameter, the holes in the tube-plate being made 51 millimeters; the tube is then expanded into perfect contact with the plate, but is not riveted or provided with a ferrule.

The steam dome is placed at about the middle of the barrel of the boiler, as shown in the engraving; it carries two safety-valves of the Meggenhoffen system.

The throttle is a valve which moves vertically on the face of the head of the cast-iron steam-pipe; to facilitate the movement of the large valve, an auxiliary valve is provided, which, by a slight movement produced at the moment when the throttle is opened, uncovers a small opening, permitting the steam to enter before the large valve moves. The engineer moves the throttle-valve by giving a rotary movement to a handle which communicates through a rod with a lever attached to the valve.



FAST PASSENGER LOCOMOTIVE, SWEDISH STATE RAILROADS.

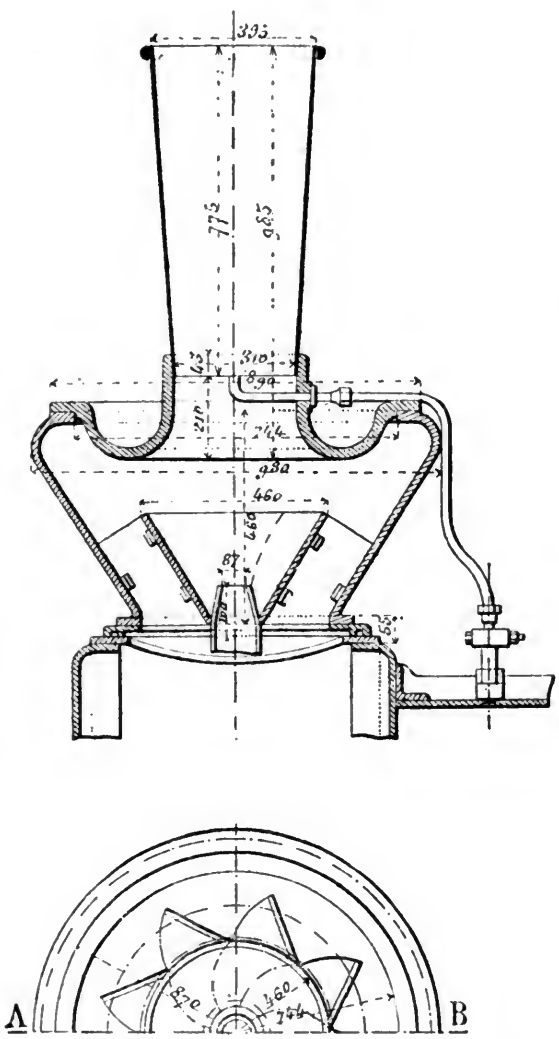
(Dimensions in Meters and Millimeters.)

The cylinders are placed outside, between the two wheels of the truck. The steam chest is placed inside and is provided with a balanced valve, similar to those used on the locomotives of the Northern Railroad of France. These valves are made of cast iron, and are formed by two flat valves or tables provided with cylindrical parts fitting into each other. The inner cylinder carries a cast-iron segment which makes a joint with the outer one. A coiled spring bearing on the bottom of each of these cylinders tends to separate the two parts of the valve and to make them bear one on the valve face, the other to the cover of the steam chest. The interior of the valve communicates directly with the exhaust.

The guide-bars are of steel cast at the Bofors factory. The cross-heads are of mild steel from the Trollhattan forges. The valves are worked by straight links of the Allan system.

The frames are of mild Bessemer steel furnished by the mills at Donmarfvet in Dalecarlia. At the rear end the weight rests on the coupled axles through springs and equalizers, by which it is distributed equally upon the wheels. The forward end is carried on the truck, as shown in the engraving.

The smoke-stack is, to our eyes, of a very peculiar form. There is a straight chimney of sheet iron of the form commonly used in Europe, but this is attached to a cast-iron base which rests directly on the smoke-box. In this base, which has the form of a reversed cone, is a second cone, the center of which is directly over the exhaust nozzle; between these two cones there is a series of curved arms very similar to the wings of a turbine. These throw the cinders against the side of the base, and they then fall back into the smoke-box. To American eyes the whole



SMOKE-STACK FOR SWEDISH LOCOMOTIVE.

arrangement seems very much like one of our diamond stacks turned upside down, with the cone at the bottom of the stack instead of the upper end. It is said, however, to give very good results.

The truck is carried upon two axles and is on Kamper's modification of the Bissell system, which is used extensively on the engines of the Franz-Josef Railroad in Austria. The center for the radius-bar is placed behind the axles, and is formed by a pin passing through a bar and having a longitudinal motion between two slides which are carried by cross-braces connecting the frames. The construction of the truck as shown in the drawing will appear to American eyes somewhat awkward and clumsy. As its motion is limited by the radius-bar at the rear end, it is regulated in front by links which are connected to lugs fastened to the bumper-bar at the front end of the frames. The weight which rests upon the truck is carried by side-bearings so arranged that it will be equally distributed.

The wheels are of wrought iron; the driving wheels are provided with counterbalances in the usual manner.

The axles are of puddled steel, made at the Surahammar shops.

The tires are of Bessemer steel made at Sandviken. Those that are used on the wheels which are exposed to the action of the brake-shoes have a somewhat smaller proportion of carbon than the others.

The axle-boxes are so made that the lubrication is entirely from above. On these engines Russian oil is used altogether. The axle-boxes are made of steel from Bofors; the pedestal jaws in which the boxes are carried are also of steel.

The driving wheels of the engine are provided with vacuum brakes of the Koerting-Sanders system. The locomotives are also provided with a counter-pressure brake system for emergencies, which is, however, very seldom used.

The total weight of these engines, when the boilers are full and ready for service, is 40.4 tons; of this 15 tons are carried on a truck and 25.4 tons on the driving wheels.

In actual service the engines first built of this pattern run between Malmo and Nassjo, making the distance from Malmo to Stockholm, which is 384 miles, in 14½ hours, with 13 stops. The average speed, making no allowance for the time lost in stopping, is about 26½ miles an hour, the usual train consisting of 12 carriages and wagons, weighing in all about 130 tons. In the summer season, however, the train is sometimes increased to 15 carriages weighing 157 tons. The limit of speed imposed on these engines is 46½ miles an hour, although one or two of them have attained a speed of 50 miles upon occasion.

While the average speed is, as above stated, only 26½ miles per hour, it is necessary at various points of an ordinary run, in order to make time, to reach a speed varying from 31 to 37½ miles an hour. The usual service of a locomotive is about 2,600 miles in winter and 3,700 in summer.

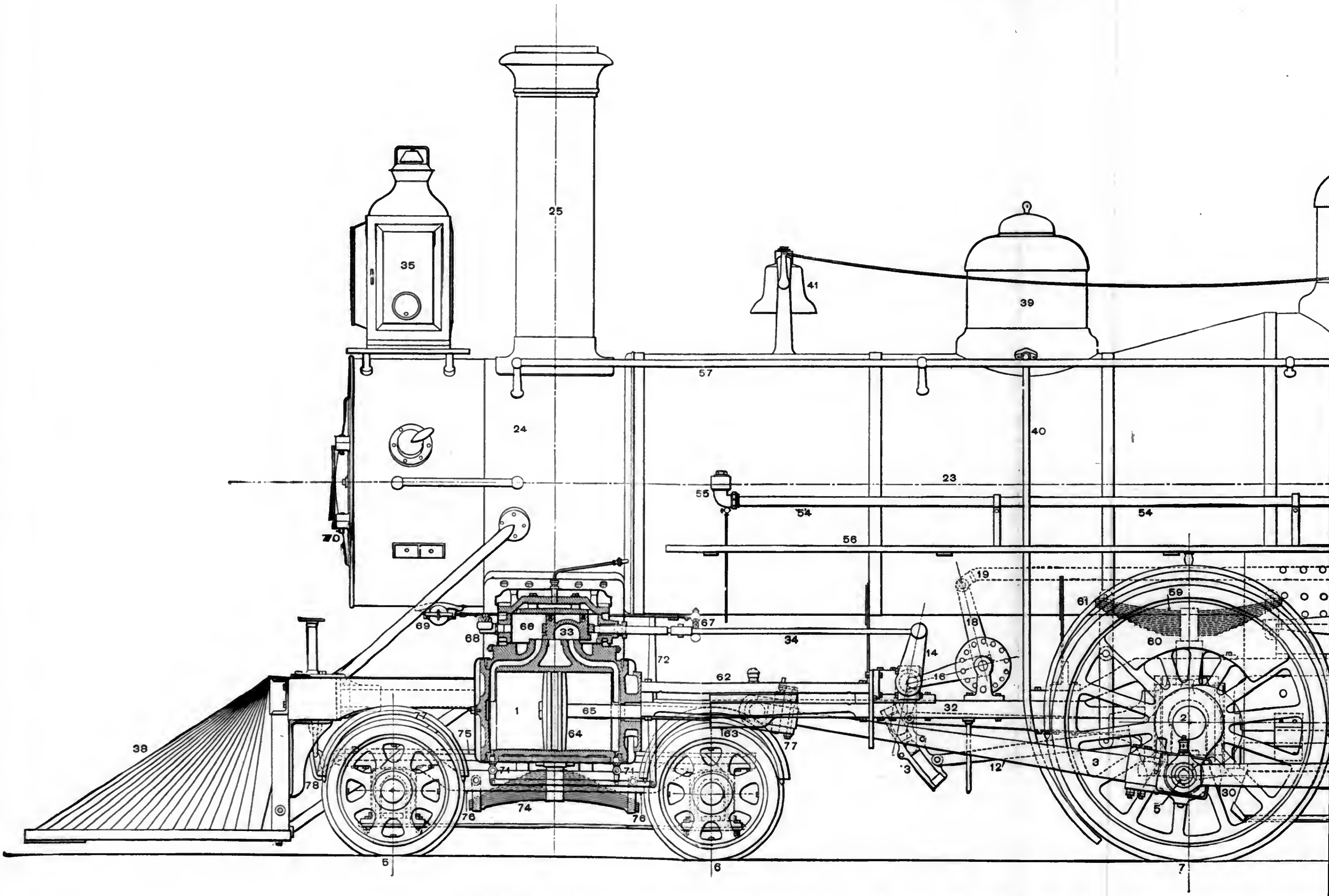
These engines have done excellent service, and since they were built have proved themselves easy upon the track and steady running engines; they pass around curves, of which there are many on the line, with great facility.

A New Dynamite Gun.

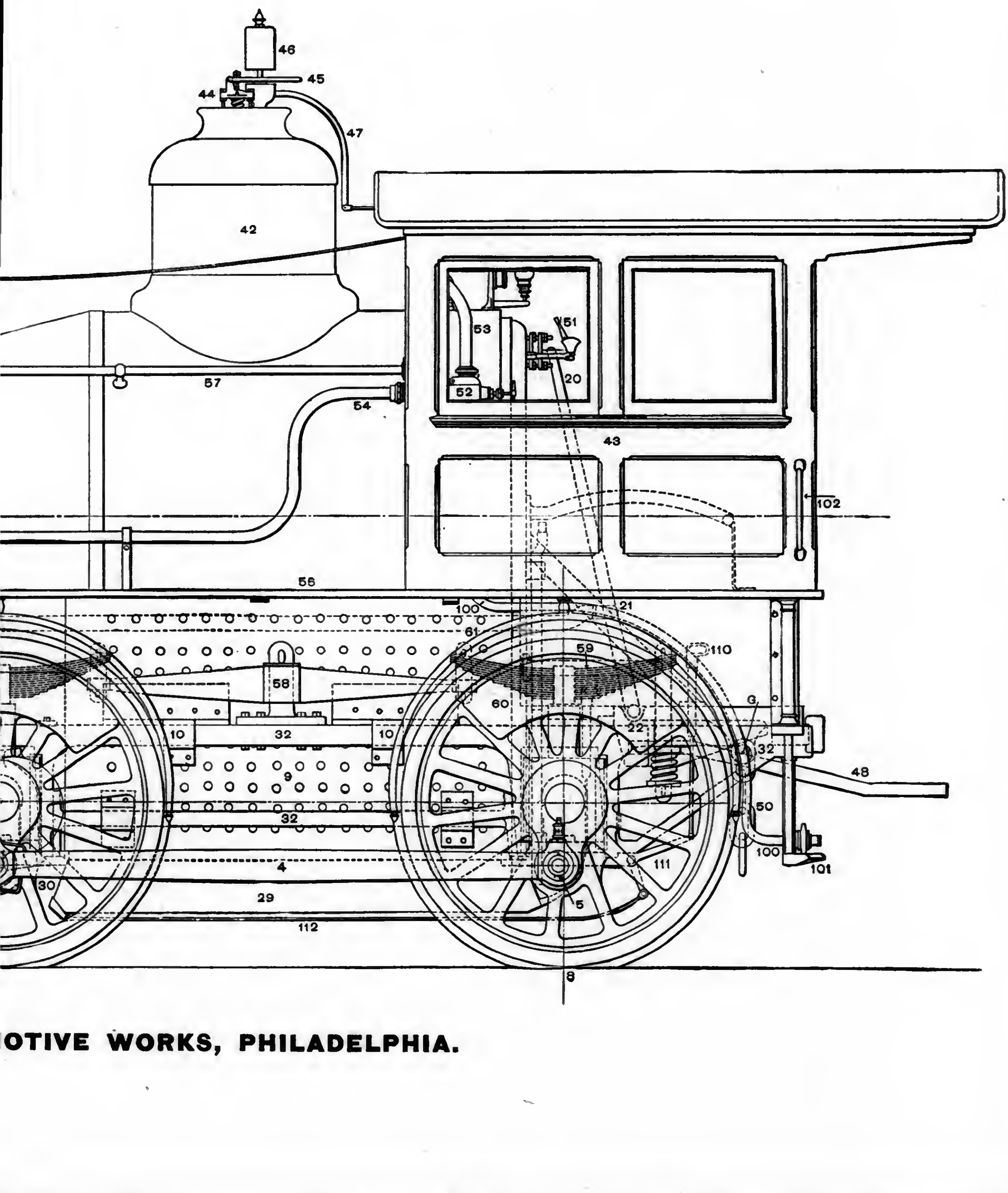
(From the *Army and Navy Register*.)

THE Ordnance Department of the Army has this week received from the celebrated inventor, Mr. Maxim, of England, the description of a new dynamite gun which he has projected, in which he proposes to introduce a new and interesting method of expelling the projectiles from the weapon, and by which he hopes to render the use of dynamite in projectiles practicable in heavy guns. He retains the pneumatic principle which has been utilized with so much success by Captain Zalinski, but instead of using compressed air alone, as Captain Zalinski has done, he mixes with this compressed air a quantity of volatile hydrocarbon, such as the vapor of gasoline. This compressed mixture is introduced behind the projectile and the pressure is applied to start it forward in the chamber of the gun. After it has moved a certain distance the projectile itself uncovers a detonating fuse and an explosion then occurs, the air furnishing the oxygen for the explosion and the pressure being increased about eight times. He claims that by this method his initial pressure does not need to be more than half as great as that used by Captain Zalinski. He does not have to use so much compressed air, nor does he require that the barrel of his gun shall be of such great length. His highest pressure is about 4,000 lbs. to the inch, the first pressure being not more than one-tenth of that. His detonator is a very ingenious affair, and is inserted through a small circular opening from the interior of the gun. The ordnance officers are much interested in this new form of the dynamite gun, which is first brought to public notice, we believe, in this article.

PLATE III.



PASSENGER LOCOMOTIVE BUILT BY THE BALDWIN LOCOMOTIVE WOR



OTIVE WORKS, PHILADELPHIA.

CATECHISM OF THE LOCOMOTIVE.

(Revised and enlarged.)

By M. N. Forney.

(Continued from page 184.)

CHAPTER XI.

GENERAL DESCRIPTION OF A LOCOMOTIVE ENGINE.

QUESTION 273. *What are the principal parts of an ordinary locomotive engine?*

Answer. A boiler for generating steam and a pair of high-pressure steam-engines, which are all mounted on a suitable frame and wheels adapted for running on a track consisting of two iron or steel rails.

QUESTION 274. *How is the power of high-pressure engines applied to locomotives?*

Answer. By connecting the engines with the wheels so as to give the latter a rotary motion.

QUESTION 275. *When they revolve what will occur?*

Answer. Either they will slip on the track, or the locomotive will move either backward or forward, according to the direction the wheels are turning.

QUESTION 276. *What will determine whether the wheels will slip or the locomotive move?*

Answer. The friction or *adhesion*, as it is called, between the wheels and the track. If this adhesion is greater than the resistance opposed to the movement of the locomotive, the latter will overcome the resistance; but if the latter is greater than the friction, the wheels will slip.

QUESTION 277. *Upon what does the amount of friction or adhesion of the wheels depend?*

Answer. Chiefly on the weight which they bear, but to some extent upon the condition of the rails. Under ordinary circumstances, the adhesion of the wheels of a locomotive is in direct proportion to the weight they carry.

QUESTION 278. *Why are two cylinders employed on locomotives?*

Answer. Because if only one was used, it would be impossible or very difficult to start the engine, if it should stop on one of the dead points.

QUESTION 279. *How is this difficulty overcome by the use of two cylinders?*

Answer. By attaching the two cranks to the same shaft or axle, and placing them at right angles to each other, so that when the one is at a dead point the other is in the position where the steam can exert the maximum power on the crank.

QUESTION 280. *How are the cranks of an ordinary locomotive made?*

Answer. They are cast in one piece with the wheels that drive the locomotive, which are therefore called *driving-wheels*. In this country the center portion of such wheels, or *wheel-centers*, as they are called, is always made of cast iron. They are bored out accurately so as to fit the axles, which are forced into the holes bored to receive them. The centers are keyed fast to the axles, so as to prevent them from turning. The wheel-centers have steel tires around the outside which are accurately turned inside, and are made a little smaller than the wheel-centers. Before they are put on the wheels the tires are expanded by heating them, and as they cool they contract, which causes them to fit tight. The axle of a locomotive engine to which the pistons are connected is called the *main driving-axle*, and the wheels attached to it the *main driving-wheels*.

QUESTION 281. *How are the general construction and arrangement of parts of a locomotive illustrated?*

Answer. By plates III, IV, and V, which represent a side view, a longitudinal section, and a plan of an eight-wheeled passenger engine built at the Baldwin Locomotive Works in Philadelphia, and by fig. 164, which is a transverse section through the cylinders, and fig. 165, which is an end view looking at the back end of the engine.*

QUESTION 282. *How are the cylinders and driving-wheels of a locomotive usually placed?*

Answer. The cylinders 1, of eight-wheeled American passenger engines, plates III, IV, and V, are placed at the front end of the locomotive, and the main driving-axle, 2, far enough behind them to permit the connecting-rods, 3, to be attached to pins, 5, in the cranks, called *crank-pins*. In this country these cranks are now universally placed on the outside of the frames, and therefore the cylinders must be placed far enough apart (as shown in fig 164 and Plate V) to permit the connecting-rods to be attached to the crank-pins. For this reason the cylinders are placed outside of the frames 32, 32, 32. The frames, it will be seen, are inside of the wheels, and the cylinders now nearly always have their axes or center-lines horizontal, although in old engines they are sometimes inclined.

QUESTION 283. *Why are more than one pair of driving-wheels necessary for locomotives?*

Answer. Because if all the weight which is needed to create the requisite adhesion of the wheels of locomotives to pull heavy loads was placed on one pair of wheels, it would be so excessive as to partly crush and injure the rails. It is therefore distributed, usually on two pairs, but sometimes on three or four or even more pairs. The cranks in the wheels on each side of the engine are connected together by rods or bars, 4, called *coupling* or *parallel-rods*, which are attached to the crank-pins, so that all the driving-wheels will revolve together.

QUESTION 284. *Where is the second pair of driving-wheels usually placed?*

Answer. These wheels, 8, 8—called the *back driving* or *trailing driving-wheels*—are, in the ordinary type of locomotives used in this country, situated behind the main driving-wheels, far enough back to give the room necessary for the fire-box between the two axles.

QUESTION 285. *How are the axles, cylinders, etc., held in the right position in relation to each other?*

Answer. By longitudinal frames, 32, 32, which hold the axles in the proper position, and are bolted to the cylinders, and also fastened to the boiler at 10, 10.

QUESTION 286. *What are the smaller wheels, 6, 6, called, and what are they for?*

Answer. They are called *truck-wheels*, and carry the weight of the cylinders and other parts of the front end of the locomotive, and serve to guide and steady the machine in a manner which will be more fully explained hereafter.

QUESTION 287. *How is a locomotive engine made to run either backward or forward?*

Answer. By having two eccentrics, 11, 11′, plates IV and V, for each cylinder. One of these is fixed or *set* on the shaft in such a position as to move the valve so that the engine will run in one direction; the other eccentric is set so that the engine will run the reverse way. The ends of each pair of eccentric rods are attached by rods 12, 12′ to what is called a *link*, 13, the object of which is to furnish the means of quickly engaging and disengaging either eccentric rod to or from the rocker, 14, 14. The rockers are connected to the main-valves, 33, by rods, 34, called *valve-stems*. The links are suspended by bars, 15, called *link-hangers*, to the ends of arms, 16, attached to a shaft, 17, called a *lifting-shaft*. This shaft has another upright arm, 18, attached to it on the right-hand side of the engine, the upper end of which is connected by a rod, 19, 21, called the *reversing-rod*, to a lever, 20, 21, and 22, called the *reversing-lever*, in the cab. The principles and operation of this mechanism will be fully explained in another chapter.

QUESTION 288. *What are the principal parts or "organs" of a locomotive boiler?*

Answer. 1. A fireplace, or, as it is called, a *fire-box*, 9.

2. A cylindrical part, 23, attached to the fire-box at one end and to a chamber, 24, called the *smoke-box*, at the other.

3. The *tubes* or *flues*, 25, 25′, Plate IV, which connect the fire-box with the smoke-box, and pass through the cylindrical part of the boiler and are surrounded with water.

4. The *chimney* or *smoke-stack*, 25.

QUESTION 289. *What is each of those parts or organs for and of what do they consist?*

Answer. The fire-box 9 furnishes the room for burning the fuel, and consists of an inner and outer shell made of boiler plate, as shown in plates IV and V, with the spaces 26, 26 between the two shells filled with water; a grate, 27, 27, formed of cast-iron bars, with spaces between them for admitting air for the combustion of the fuel, which is placed on top of them; a door, 28, called the *furnace-door*, for supplying the grate with fuel; a receptace, 29, below the grate, to collect ashes, and therefore called the *ash-pan*, which is supplied with suitable dampers, 30 and 31, for admitting or excluding the air from the fire.

The cylindrical part 23, or *waist* of the boiler, as it is sometimes called, contains the greater part of the water to be heated.

The *flues* or *tubes*, as they are generally called, are usually 2 in. in diameter and from 10 to 12 ft. long. The number of tubes in a locomotive boiler varies with its size. A boiler of the size shown in the illustration has about 250 tubes. They conduct the smoke and products of combustion from the fire-box to the smoke-box. The tubes are made of small diameter so as to subdivide the smoke into many small streams and

* The same figures indicate the same parts in all these engravings.

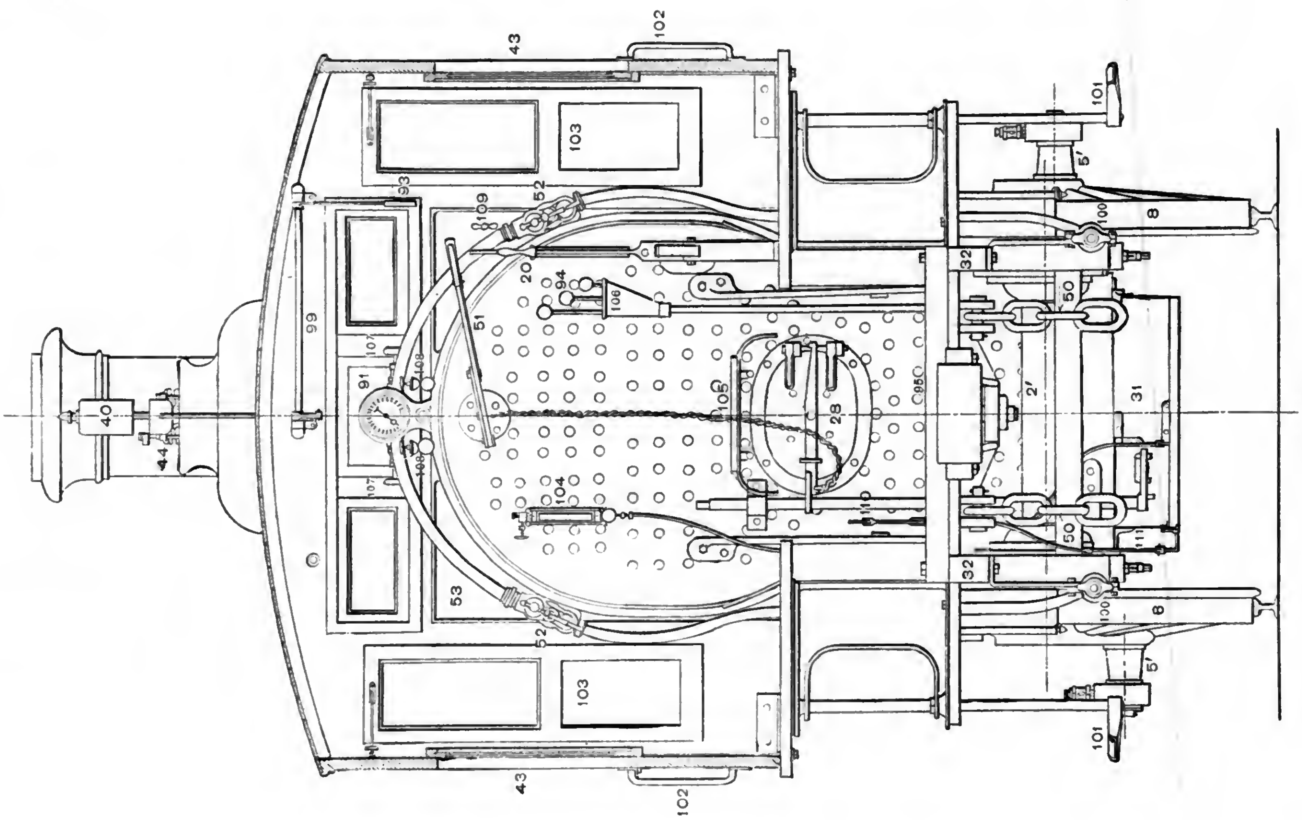


Fig. 165.

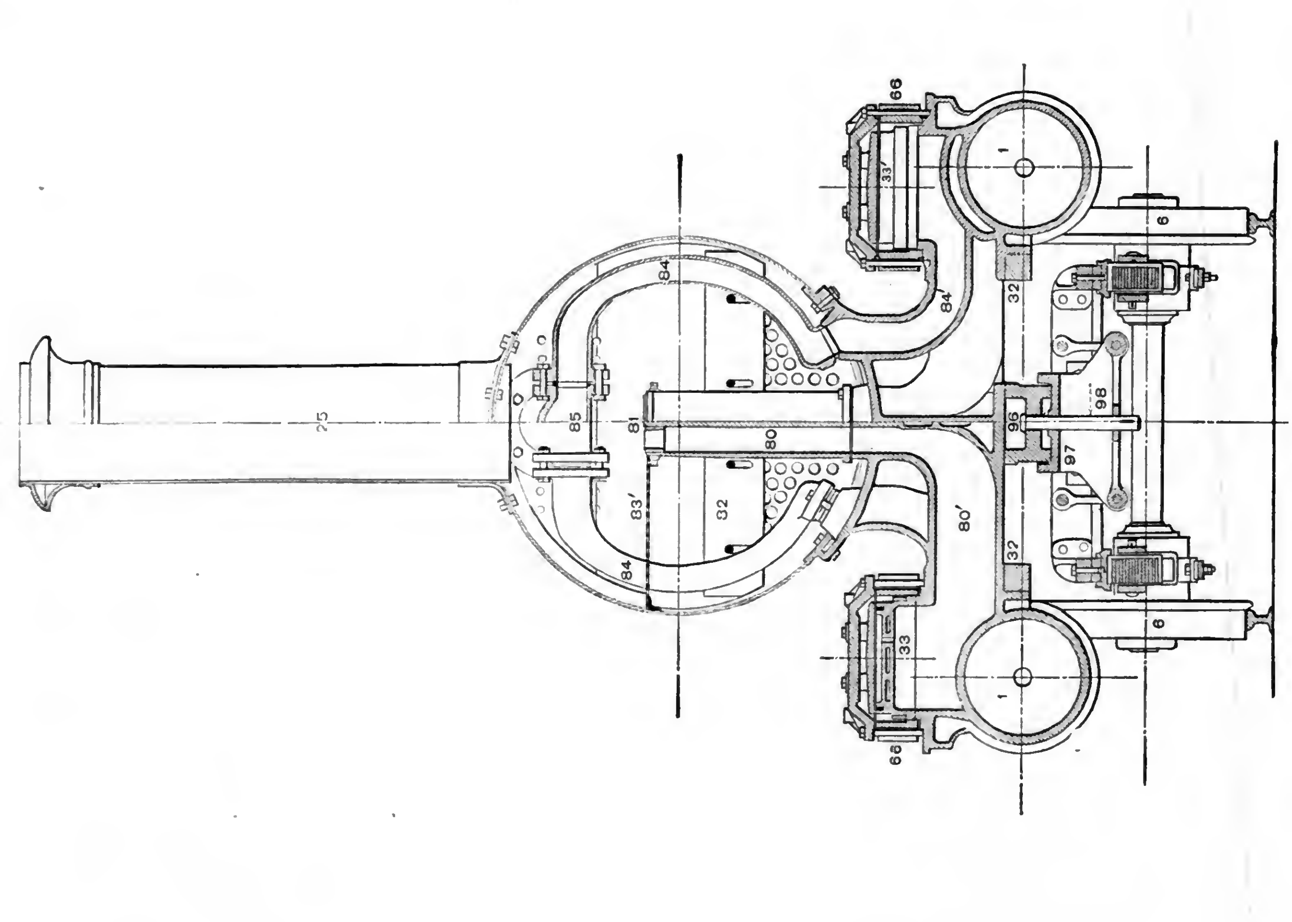


Fig. 164.

PASSENGER LOCOMOTIVE BUILT BY THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA.

thus expose it to a large radiating surface through which the heat is conducted to the water.

The chimney or smoke-stack serves partly for removing into the open air the smoke which passes through the flues, and partly for producing a strong draft of air, which is indispensably necessary for the rapid combustion of the fuel. Smoke-stacks are also often provided with arrangements for arresting the sparks and cinders which escape from the fire.

QUESTION 290. *What is a locomotive head-light, and what is it for?*

Answer. A *head-light* is a large lamp, 35, which is placed on the front end of a locomotive to light up the track in front of it and give warning of its approach.

QUESTION 291. *What is a cow-catcher, and what is it for?*

Answer. A *cow-catcher*, 38, as its name implies, is intended to "catch cows" or other obstructions on the track and throw them off, thus preventing them from getting under the wheels while the engine is running. It is a triangular-shaped structure made of wooden or iron bars and attached to the front of the engine.

QUESTION 292. *What is the sand-box on a locomotive for?*

Answer. The sand-box, 39, is usually placed on top of the boiler, and has pipes, 40, on each side of the engine by which sand is conducted to the rails in front of the driving-wheels, to prevent them from slipping when the engine is working hard.

QUESTION 293. *What is the cab of a locomotive for?*

Answer. A cab, 43, is for the protection of the men who run the engine from rain, cold, and sunshine.

QUESTION 294. *How is the locomotive connected to the train behind it?*

Answer. By an iron bar, 48, called a draw-bar, which is attached by a pin, 49, to a casting on the back end of the engine. The draw-bar is coupled to the tender behind the engine by another pin similar to the one on the engine. The engine and tender are also coupled together by chains, 50, called safety-chains. These are used as a safeguard to prevent the engine and tender from separating in case the draw-bar should break.

QUESTION 295. *How are the water and fuel carried which must be supplied to a locomotive while it is running?*

Answer. The water is carried in a tank, which is usually constructed in the form of a letter **U**, so as to give room for the stowage of fuel between its two branches or sides, and is carried on a set of wheels, which forms a separate vehicle, independent of the locomotive, called a *tender*, the construction of which will be explained in a future chapter. In another class of engines, called *tank-engines*, the water-tank and fuel are carried on the engine.

The following is a list of parts designated by the numbers on plates III, IV, V, and figs. 164 and 165:

1 Cylinders.
2 Main driving-axle.
3 Connecting-rod.
4 Coupling-rod.
5 Main crank-pin.
6 Truck wheels.
7 Main driving-wheels.
8 Back driving or trailing wheels.
9 Fire-box.
10 Expansion clamps.
11 Eccentrics.
12 Eccentric-rods.
13 Link.
14 Rocker.
15 Link-hanger.
16 Horizontal arm of lifting-shaft.
17 Lifting-shaft.
18 Upright arm of lifting-shaft.
19 Reversing-rod.
20, 21, 22 } Reversing-lever.
23 Cylinder, or waist of boiler.
24 Smoke-box.
25 Chimney or smoke-stack.
26 Water spaces.
27 Grate.
28 Furnace-door.
29 Ash-pan.
30 Front ash-pan damper.
31 Back ash-pan damper.
32 Frames.
33 Main-valve.
34 Valve-stem.
35 Head-light.
36 Head-light reflector.
37 Head-light lamp.
38 Cow-catcher.
39 Sand-box.
40 Sand-pipes.
41 Bell.
42 Dome.
43 Cab.
44 Safety-valve.
45 Safety-valve lever.
46 Whistle.
47 Whistle-lever.
48 Draw-bar.
49 Coupling-pin.
50 Safety-chains.
51 Throttle-lever.
52 Injector.
53 Injector steam-pipe.
54 Injector feed-pipe.
55 Injector check-valve.
56 Running-board.
57 Hand-rail.
58 Equalizing-lever.
59 Driving-springs.
60 Counter-balance weights.
61 Driving-wheel guard.
62 Guide-bar.
63 Cross-head.
64 Piston.
65 Piston-rod.
66 Steam-chest.
67
68
69
70 Smoke-box door.
71 Cylinder-cocks.
72 Cylinder-cock lever.
73 Cylinder-cock shaft.
74 Truck-spring.
75 Truck-frame.
76 Truck equalizing-lever.
77 Truck wheel-guard.
78 Truck check-chain.
79 Push-bar.
80 Exhaust-pipes.
81 Exhaust-nozzle.
82 Deflector.
83 Wire-netting.
84 Steam-pipe.
85 T-pipe.
86 Dry-pipe.
87 Throttle-pipe.
88 Throttle-valve.
89 Throttle-stem.
90 Throttle bell-crank.
91 Steam-gauge.
92 Steam-gauge lamp.
93 Whistle lever.
94 Gauge-cocks.
95 Foot-board.
96 Truck center-bearing.
97 Truck center-plate.
98 Truck center-pin.
99 Whistle-shaft.
100 Suction-pipes.
101 Foot-steps of cab.
102 Hand-holds of cab.
103 Front door of cab.
104 Water-gauge.
105 Stand for oil-cans.
106 Drip for gauge-cocks.
107 Injector-valve.
108 Oil-cup for oiling main valves.
109 Handle for opening valves in sand-box.
110 Handle for opening front damper.
111 Bell-crank for opening front damper.
112 Rod for opening front damper.
113 Mud-plugs.

CHAPTER XII.

THE THROTTLE-VALVE AND STEAM-PIPES.

QUESTION 296. *How is the steam admitted to and the supply regulated or shut off from the cylinders?*

Answer. By a valve, *T*, fig. 90, called a *throttle-valve*, which is usually placed at the end of the pipe *O O' Q*, near the top of the dome. Throttle-valves are sometimes placed in the smoke-

box at the front end, O, of the dry-pipe. Until within a few years they consisted of plain slide-valves which covered openings similar in form to the steam-ports, but smaller in size. The pressure on such valves is of course greatest when there is no steam underneath, which is the case when the valves are closed. It is then very difficult to open them, and as it is important that the supply of steam admitted to the cylinders when the locomotive is started should be easily regulated, such valves are objectionable, and therefore the form has been introduced which is illustrated in fig. 90, and also on a larger scale in figs. 166 and 167, which represents a longitudinal section and plan of the throttle-pipe valve and throttle lever. The valve T is what is called a *double-poppet valve*, and consists of two circular disks, a and b, which cover two corresponding openings in the end of the pipe Q. When these disks are raised up, as shown in fig. 166, steam flows in around their edges, as represented by the darts. It will be observed that the steam pressure in the boiler comes on top of the disk a and against the under side of b. The pressure on the one thus neutralizes or balances that on the other. If the two disks were of the same size, the pressure of the one would be exactly the same as on the other; but as they are joined together and are made to fit steam-tight on their seats by *beveled joints*, their diameters must be somewhat larger than the openings they cover. The only practicable way, therefore, by which the lower disk b can be introduced into the upper end of the pipe Q so as to cover the lower opening is through the upper opening a. For this reason the lower disk must be made

latch is operated by a trigger, k, which is connected to the latch by a rod, r. Various other devices are used to fasten throttle-levers and thus hold them in any position required.

QUESTION 298. *How are the steam-pipes constructed?*

Answer. The steam, after it is admitted by the throttle-valve, as was explained in answer to Question 296, passes into the throttle-pipe Q and the dry-pipe O' O, fig. 90. At the front end of the dry-pipe a pipe, O, which divides into two branches like the top of the letter T, and is therefore called a T-pipe, is attached. This pipe is indicated by number 85 in fig. 164. The steam-pipes 84, 84, fig. 164, are connected to each of the two branches of the T-pipe at one end and to the cylinders at the other.*

These pipes, being in the smoke-box, are exposed to great changes of temperature, and are therefore subjected to expansion by heat and contraction by cold. The joints are therefore constantly liable to disturbance by the contraction and expansion of the pipes, and so are difficult to keep tight. It is also practically impossible to construct the boiler, the cylinders and the pipes with perfect accuracy, and therefore a small amount of adjustability and flexibility is necessary in the joints of the pipes. If, for example, the upper end of the pipe 84' in the cylinder, fig. 164, were either too near or too far from the center of the engine, it would be necessary to move the end of the pipe 84 either to the right or to the left in order to connect it with 84'. If the joint of the upper end of the steam-pipe were attached to the T-pipe with a flat joint like that shown at a b, fig. 168, it

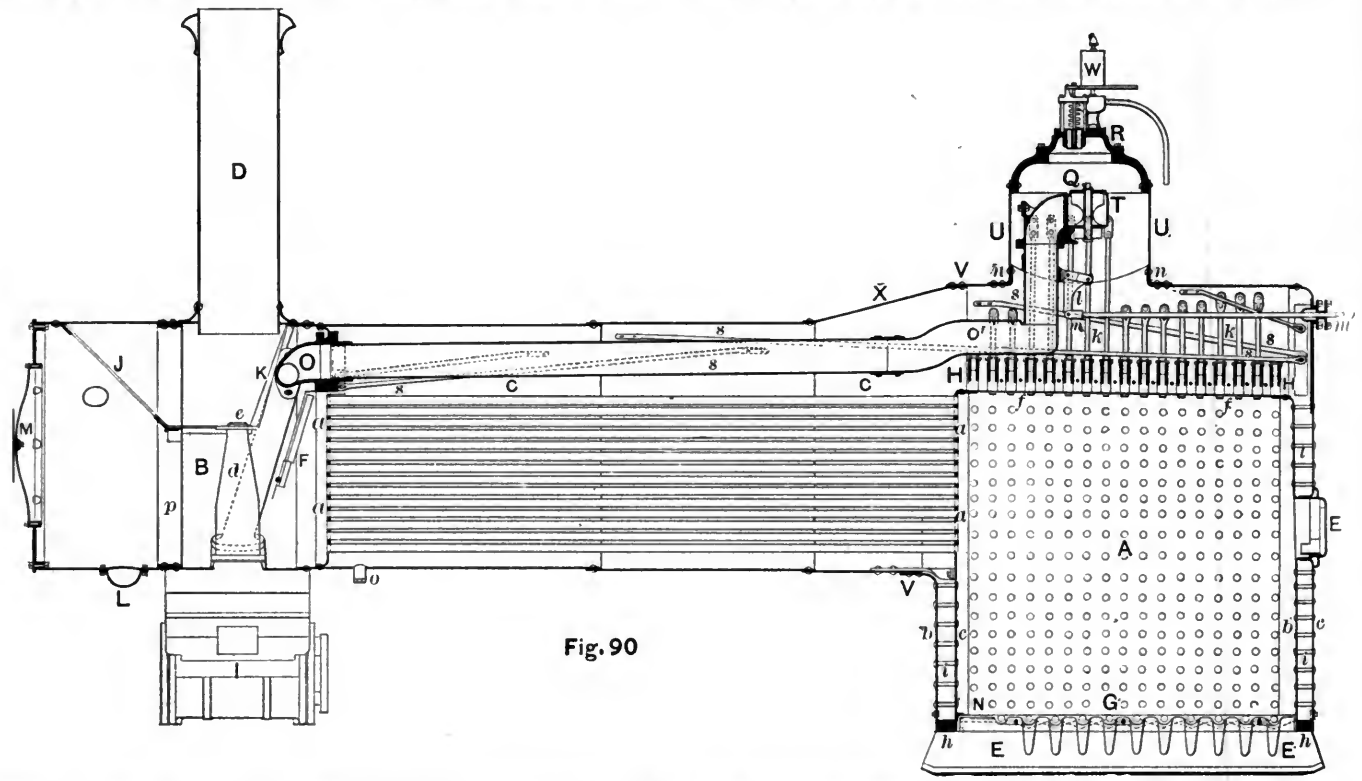


Fig. 90

smaller than the upper one, and therefore the pressure on the upper one, being in proportion to its size, is in excess of that on the lower one and has a constant tendency to close the valve. As it is of the greatest importance that a throttle-valve should remain closed after steam is shut off, and never be opened at any time accidentally, the arrangement described accomplishes just what is needed—that is, makes the valve work comparatively easily, and at the same time keeps it closed after the steam has been shut off.

QUESTION 297. *How is the valve opened and closed?*

Answer. By a lever, A B C, called a *throttle-lever*, figs. 166 and 167.* This lever is connected by a rod, d B, called the *throttle-stem*, with the lower arm of the bell crank, d c e, the other arm of which is connected by the rod e f with the throttle-valve T. The rod d B works through a steam-tight stuffing-box, E, in the back end of the boiler. The end of the throttle-lever is attached to a link, D C, fig. 167, which is fastened by a pin to the stud D. This link has a slight vibratory motion, which enables the pin B, by which the lever A B C is fastened to the rod d B, to move in a straight line, which is necessary in order that the rod may work steam-tight in the stuffing-box, E. The throttle-lever has a latch, l, which gears into a curved rack, n m, so as to hold the lever and valve in any required position. This

* Fig. 167 is a plan of the valve and lever.

would be impossible to move the lower end of the steam-pipe either to the right or to the left without disturbing the joint and causing it to leak. For this reason these pipes are connected with what are called *ball-joints*, fig. 169—that is, the end a b of

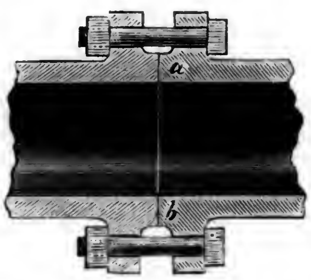


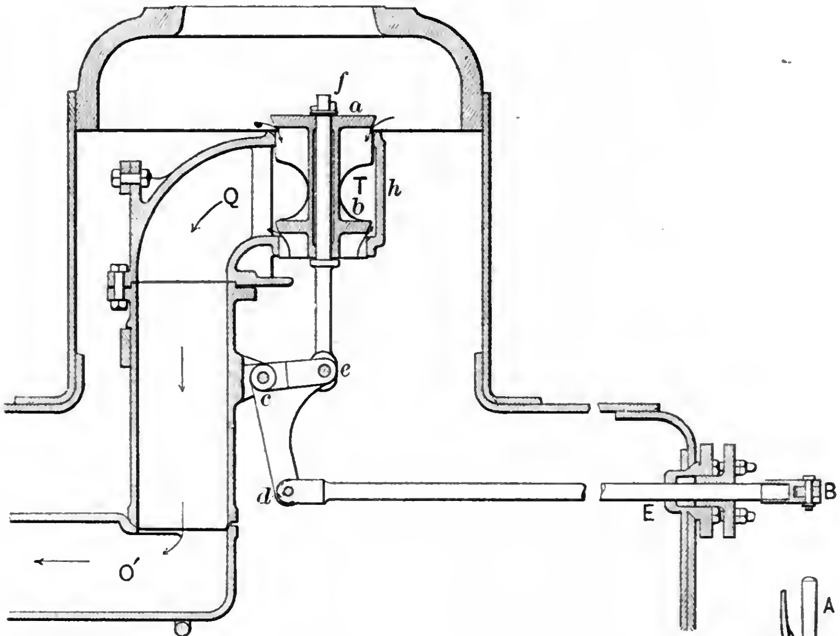
Fig. 168.

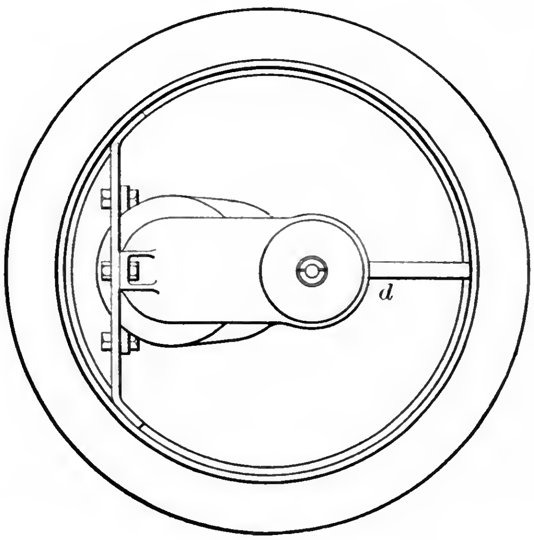
one of the pipes is turned into the form of a part of a sphere,† and the end of the other one into a corresponding concave form. It is known that a sphere will fit into a spherical socket in any position; for example, an acorn in its cup or the bones at the

* In fig 164 the right-hand side represents a section through the steam-pipe 84, 84', and the left a section through the exhaust pipe 80'.

† The dotted lines indicate what would be the form of the sphere if the pipe was solid instead of hollow.

Fig. 166.





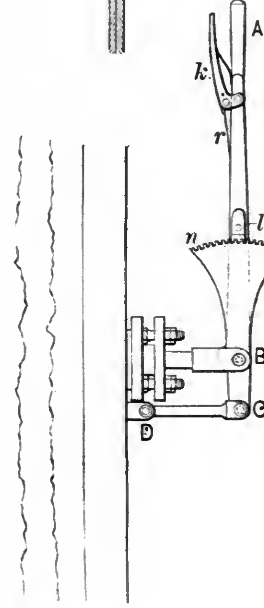


Fig. 167.

hip or shoulder joints. If, therefore, the pipes are joined with such spherical or *ball-joints*, as they are called, the lower end can be moved sideways several inches either way, and the joint will still be steam tight if it is then firmly bolted together. Even after it is bolted together it will have so much flexibility

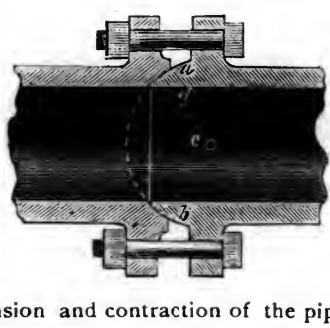


Fig. 169.

that the expansion and contraction of the pipes will not cause it to leak.

There is, however, still another difficulty. Although the lower end of the pipe, 84, fig. 164, can, with a ball-joint above, be moved in any direction horizontally, yet if the pipe is too long or too short it is obvious such a joint will not permit it to be moved up or down. A joint with a flat surface, like that shown in fig. 168, would, however, permit such motion in the pipe without leaking. If, for example, the steam-pipe were ⅛ in. too short, it might be drawn down that distance, and if the upper joint were then screwed up it would still be steam-tight. In order, then, to get both vertical and lateral flexibility in the joints of the steam-pipes, a ring, *a b*, fig. 170, is interposed between the pipes. One side of this ring is spherical and the other flat, so that the pipes can move either around the spherical part or slip up or down or sideways on the flat surface of the ring. In this way the pipes are flexible and adjustable in every

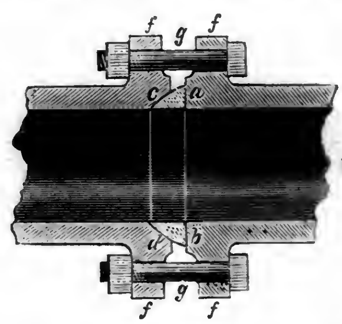


Fig 170

direction, and for all kinds of motion caused by expansion, or which may be needed when the parts are put together. Sometimes the joints at one end only of the steam-pipes are made in this way, and the other is connected with a simple ball-joint.

In designing these joints their form should be drawn with a radius, *c d*, fig. 169, from one center, *c*, so that the surface of the joint will form a part of a sphere. If they are drawn from two centers, as is sometimes done, it is obvious that the surface of the joint will not be a part of a sphere, and therefore will not have the requisite flexibility. The surfaces of the joints are

carefully turned to the proper form, and then made steam-tight by scraping or grinding them with emery and oil, and the pipes are then fastened together with bolts, *g*, *g*, fig. 170, and flanges, *f f*, cast on the pipes.

QUESTION 299. *How are the exhaust pipes made?*

Answer. They are made of cast iron. Two forms of such pipes are shown by figs. 171 to 176. These figures show vertical sections, plans, and inverted plans of the pipes. In some cases a single blast orifice or exhaust nozzle is used, as shown in figs. 171 and 172, and in others they are made double, as they are represented in figs. 174 and 175. When two nozzles are used they are

Fig. 171.

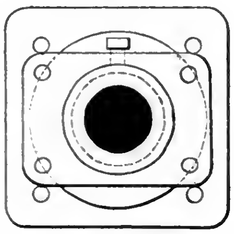


Fig. 174.

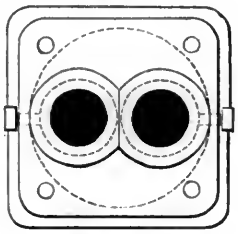


Fig. 172.

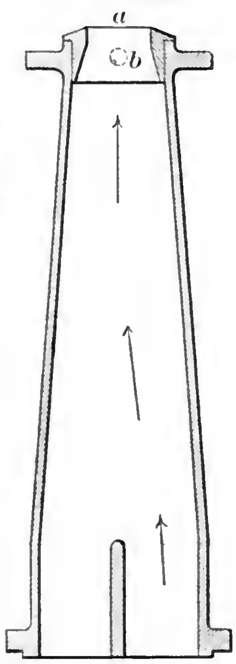
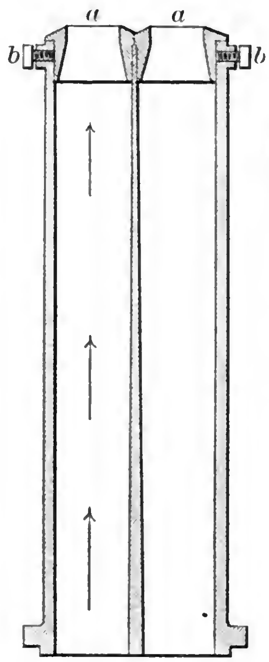


Fig. 175.



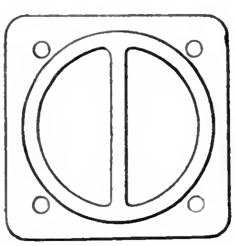


Fig. 173.

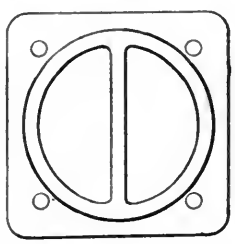


Fig. 176.

generally cast together, as shown in figs. 174–176. When only one is used, the form of the pipes resembles somewhat that of an inverted letter λ, as shown in fig. 172, so as to cover the two openings which connect with the cylinders. The tops of these pipes have rings or bushings, *a a*, fitted into them, which are held by set screws, *b*, so that they can easily be removed and others with larger or smaller openings be substituted. If the openings in the exhaust-nozzles are small, the steam must be discharged at a higher rate of speed, in order to exhaust that which is in the cylinders, than if the blast orifices are larger. Therefore, if the latter are reduced in size, the draft becomes more violent, but at the same time the *back-pressure* in the cylinder (which will be explained hereafter) is increased. It therefore becomes necessary to adjust the size of the blast orifices with the greatest care, so as to have them just small enough to produce the required draft and yet leave them as large as possible, so as to reduce the back-pressure. For these reasons what are called *variable exhausts* are sometimes used. In these the blast orifice can be increased or diminished at pleasure, and thus regulated to suit the conditions under which an engine is working. A great variety of such devices has been used, but now nearly all have been abandoned for the simpler arrangement described, which is not variable when the engine is working.

(TO BE CONTINUED.)

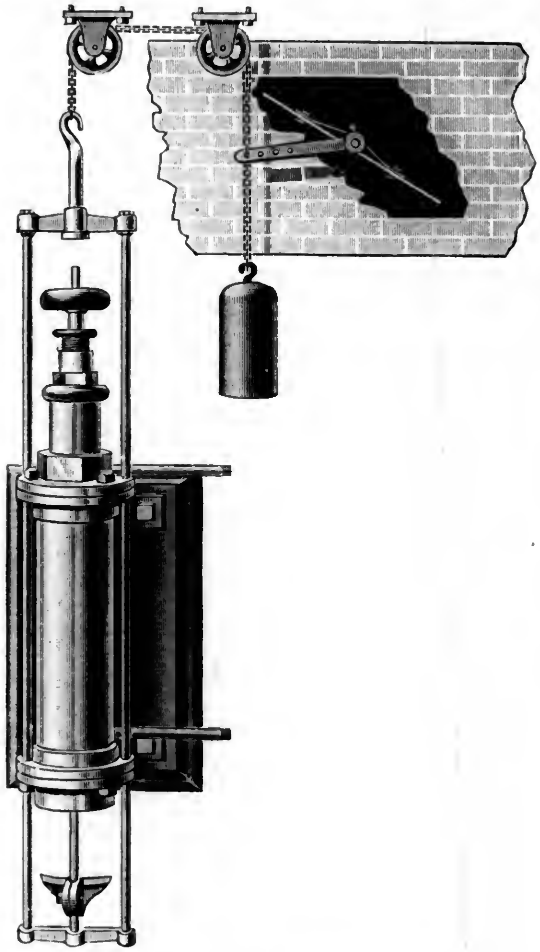
Manufactures.

The Curtis Damper Regulator.

THE accompanying illustrations show an improvement which has been made in the damper regulator manufactured by the Curtis Regulator Company, of Boston. In this device the principles contained in the Curtis pressure regulator have been applied to the movement of a damper in the flue of a steam boiler, so as to obtain great uniformity of boiler pressure.

Many of them close and open the damper with a change of boiler pressure inside of 1 lb., and maintain the pressure with very slight variations.

The full view shows the improvement as attached to a damper, and the sectional view shows the operating parts. Steam is



THE CURTIS DAMPER REGULATOR.

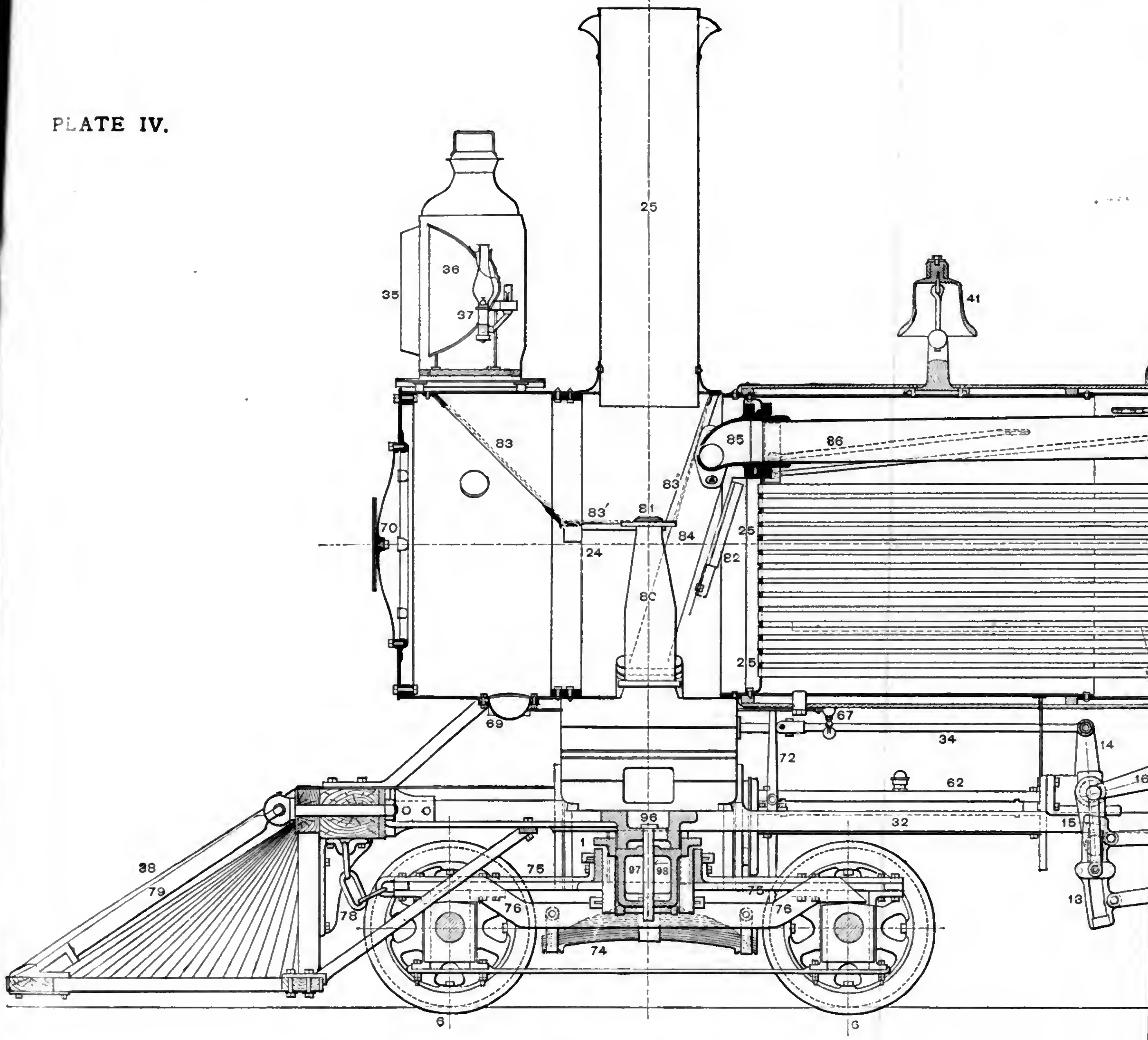
brought in a ½-in. pipe from the boiler to the chamber surrounding the valve *E*. This pressure is also carried through the side pipe *A* to the diaphragm.

By turning down on the handle *H* the spring *S* is compressed, loading the diaphragm with any given weight, thus holding the valve *E* on its seat.

When the boiler pressure in the valve chamber rises high enough to lift this load the valve opens, say 0.01 in., admitting the steam on top of the piston *P*, pushing it down to the bottom of its stroke, overhauling the chain and closing the damper.

The latest improvement consists in extending the stem *D* of the follower (which rests on the phosphor-bronze diaphragm) up through the handle to such a length that the yoke rests on it when the damper is sufficiently closed, and forces the valve *E* to its seat, cutting off the flow of steam into the piston chamber.

PLATE IV.



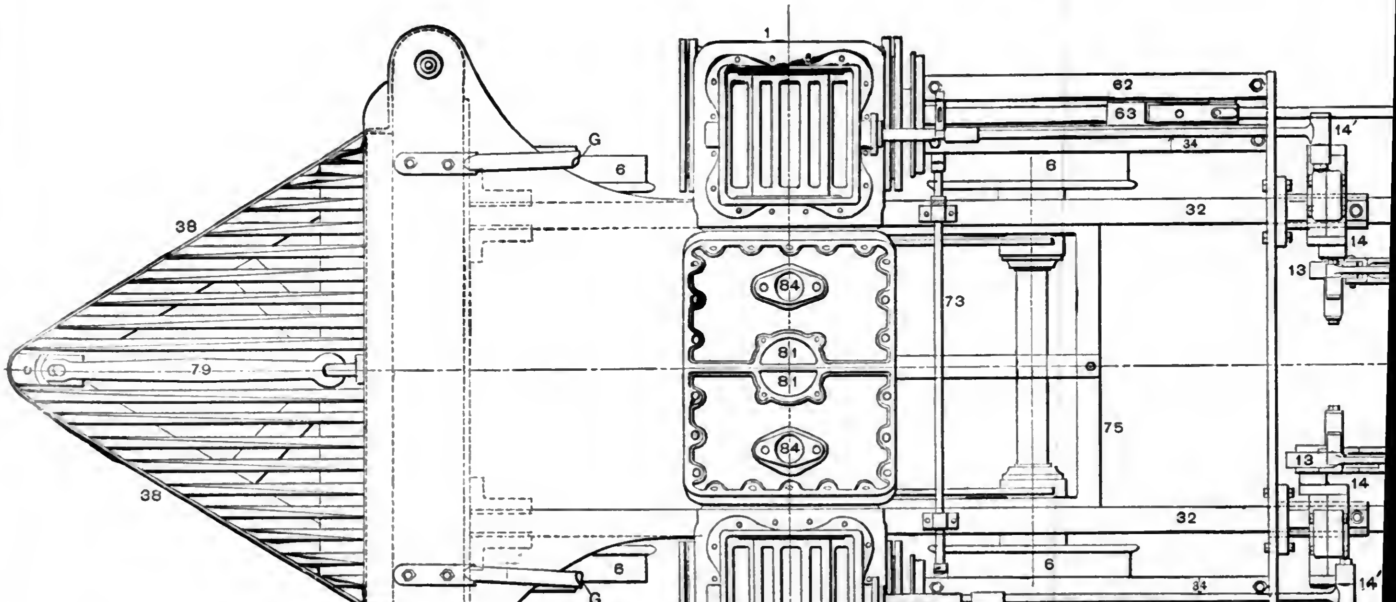
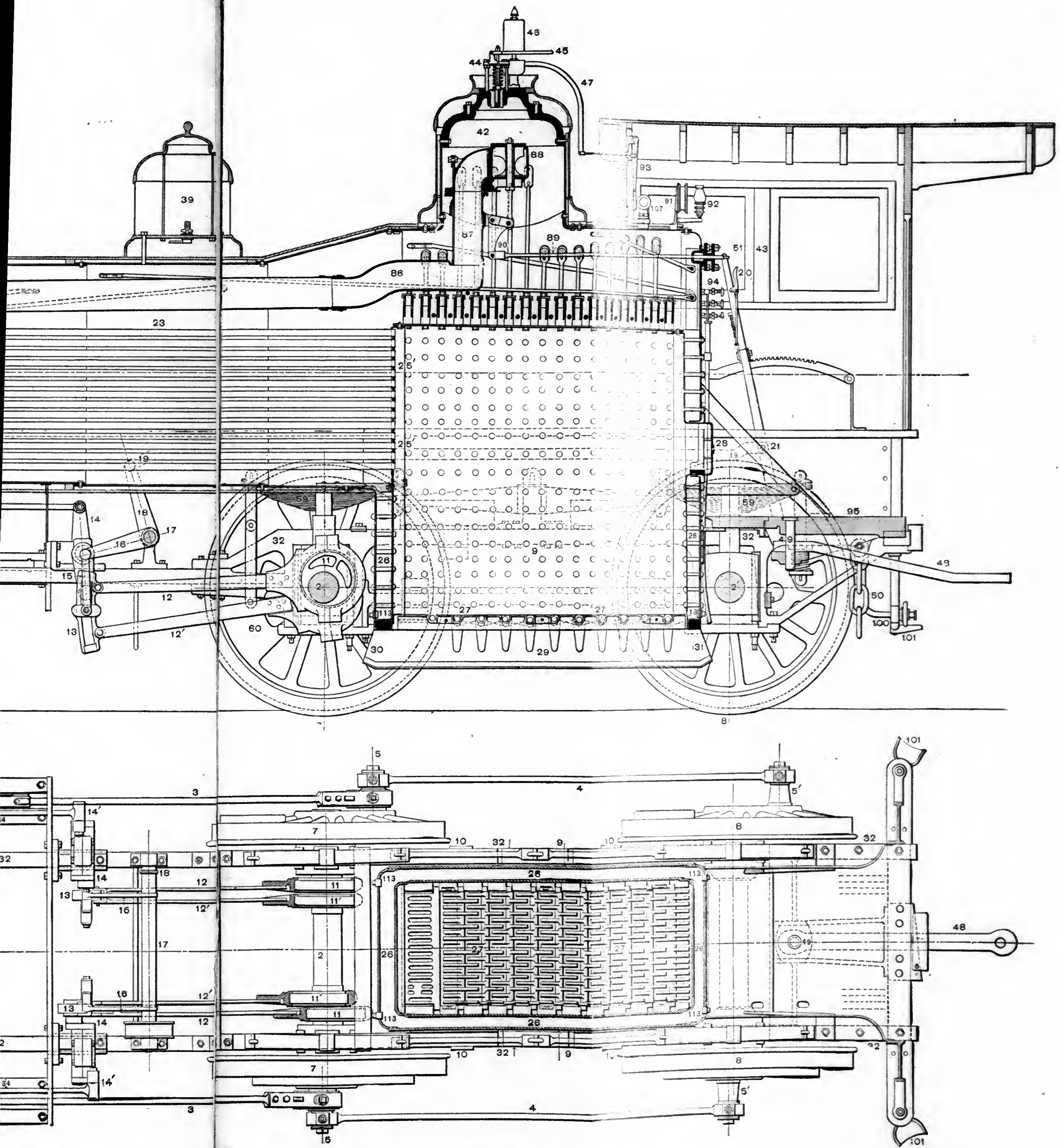


PLATE V.

PASSENGER LOCOMOTIVE BUILT BY T



UILT BY THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA.

lo
tig
pe

vi
pr
ap
st
pr
ari

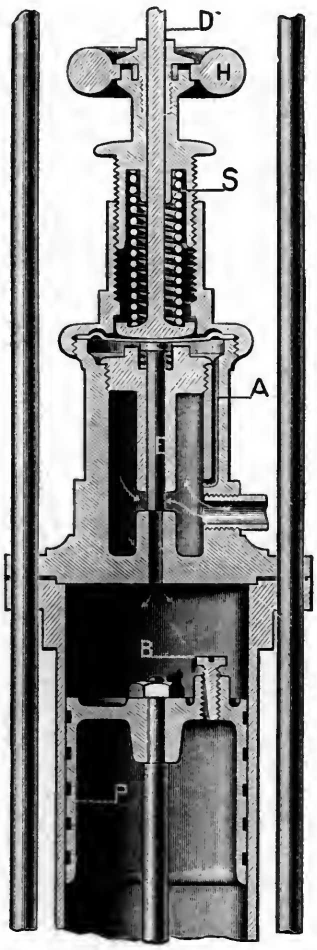
co
cl
Co
si
lbs
fe
T
26
ne

re
Co
Ba
pe
de
H
ir
ar

The piston, starting back, relieves the pressure on the spindle *D*, permitting the valve *E* to open again, providing just the needful pressure in the cylinder to hold the damper closed until the boiler pressure falling, say ½ pound, has no longer power to open the valve, and the weight opens the damper.

The condensation in the chamber over the piston passing through the adjusting screw *B* is carried away by a small drip-pipe into the ash-pit.

Another improvement consists in making the piston *P* quite



long, a loose fit, and putting in water grooves, which make a tight water packing to a perfectly free piston which, from experience at work, has proved very effective.

The special object sought in this regulator has been to provide a device which shall be sensitive and at the same time proof against the rough usage and neglect which a boiler and its appendages sometimes, unfortunately, receive. In this, the steam being taken at full boiler pressure, there is sufficient power provided to move the regulator under any difficulties likely to arise in practice.

Marine Engineering.

THE Cleveland Shipbuilding Company in Cleveland, O., has completed a thorough reconstruction of its yard and plant, including a considerable extension of its shop facilities. The Company has on hand contracts to build five large triple-expansion engines, ten large Scotch boilers capable of carrying 150 lbs. of steam, and three steel steamers. One of these is a ferry-boat; the other two are freight boats for the Lackawanna Transportation Company. They will be 280 ft. long over all, 260 ft. keel, 38 ft. beam, and 25 ft. hold. The first one is nearly finished.

THE Harlan & Hollingsworth Company in Wilmington, Del., recently launched a new steamboat for the Maryland Steamboat Company. The new boat, which is intended for Chesapeake Bay service and is called the *Avalon*, is 190 ft. between perpendiculars, 200 ft. over all, 31 ft. breadth of beam, 10 ft. depth from base line to under side of deck at the lowest place. Her hull is of iron, double riveted, and has three bulkheads of iron, which will form water-tight compartments. The wheels are 22 ft. in diameter and have 12 buckets to each wheel. The boiler is cylindrical flue and return tubular, tested to 60 lbs. to the square inch, and is 18 ft. long and 11½ ft. in diameter. The steamboat is furnished with a vertical working beam engine 40 in. diameter and 10-ft. stroke, with Stevens adjustable cut-off and one donkey engine for fire. She will be furnished with Edison's electric lights, and will be provided with a search light on forward deck.

THE latest improvements in tank steamers built for the transportation of oil in bulk are the *Ocean* and *Chester*, just built by Russell & Co., of Glasgow, for Hermann Strusberg & Co., of New York. They are built of steel, 310 ft. long, and carry 3,500 tons of oil and 300 tons of coal. The boilers and machinery are entirely cut off from the oil tanks, which occupy 200 ft. of the vessels' length. There are 16 tanks which hold about 220 tons of oil each, and above the tanks and between the deck spaces are eight towers of 30 tons capacity each. These towers are for the purpose of keeping the tank full always, and thus secures the safety of the vessel, which might otherwise be endangered by the expansion and contraction of the oil. The 3,500 tons can be pumped out in 24 hours by the improved pumping facilities. The electric light is used, which is manufactured below decks to prevent the compass being affected by electricity.

THE Delaware River Shipbuilding Works at Chester, Pa., are building a new freight steamer for the Ocean Steamship Company, of Savannah. This vessel, which will be called the *City of Birmingham*, is expected to steam 11 knots with 2,300 tons cargo on board, besides coal enough for the round trip, on a draft of 16½ ft. of water. The principal dimensions are as follows: length, 320 ft. over all; breadth of beam, 42½ ft.; depth of hold, 26½ ft. The motive power will consist of a triple-expansion engine 24 in. high pressure, 38 in. intermediate, and 63 in. low pressure, cylinder with 45 in. stroke of piston. She will have piston valves on the high pressure, and slide valves on the low and intermediate cylinders. Four Sprang steel boilers will generate steam up to 160 lbs. pressure, and Montgomery's corrugated furnaces, made by the Continental Iron Works, of Greenpoint, L. I., will be supplied. Her decks will be three in number, with an additional deck running aft from the pilot house. She will have three large freight ports on each side. The officers' quarters and a large donkey boiler will be located on the spar-deck. She will be provided with steam steering gear and steam capstans, and will have electric lights.

Electric Haulage in Mills.

ABOUT four months ago an installation was made at the Tremont and Suffolk Mills, at Lowell, Mass., which has excited considerable interest among mill men in that section of the country. One of the difficulties to be met in this, as in other large mills, is the transporting and handling of cotton bales and heavy cases of cotton goods by the slow and expensive work of the ordinary day laborer. As the present buildings are located, all freight is received and delivered from one place. This necessitates some method of distributing the freight, such as cotton bales, etc., from this spot, and also the gathering of the manufactured goods from over the mills and the storing of the same at the freight house. In order to accomplish this work by the aid of electricity, plans were submitted by the Thomson-Houston Electric Company, and in a few weeks a motor was designed and placed upon the specially constructed car of the superintendent. For the last three or four months this motor has been running, giving perfect satisfaction.

The total distance of the road is 800 ft., running from one building across a bridge into another building and the entire length of the latter. This line is not a level one throughout, since the passage from one building to another introduces a grade of 3 to 3½ per cent. The system used is the single-wire overhead method, the rails answering for the return. The motor has a capacity of about four tons, and the gauge of the track is 4 ft. 8½ in. The controlling arrangements consist simply of a reversing switch, a speed regulator and a brake handle, which have acted without failure through very trying work. From the day of its starting no trouble whatever has been experienced, and the mill owners are perfectly satisfied with its operation, and we believe that they contemplate a considerable extension to this line, as they find that it is one of the most convenient mechanical arrangements which they have about their whole mill.

A prominent mill engineer who got on the car recently and took several rides and examined its operation very closely said that this system of collecting goods and carrying them to focal points is destined to a very general adoption.

If our readers are familiar with these large mills and the great floors several hundred feet long, they will readily see that a

narrow-gauge track, running the entire length of the room upon the floor, can be laid, and a small platform motor used to gather the cloth as it is taken from the machines. The success of this installation has brought about a number of important arrangements, and we understand that the company, realizing its great importance, are preparing for a very extensive line of work in this direction.—*Electrical World.*

The Keystone Seal Lock.

IT would be a surprise to most persons to find how much ingenuity has been exercised in devising car seals of different kinds. They have been made in an endless variety of forms, with all kinds of ingenious devices to prevent their being tampered with, and to preserve their integrity and that of the contents of the receptacle which they are intended to guard. One of the defects, characteristic of many of them, is that they are not strong enough. They are made of flimsy wire or other attachments which would not stand hard service. Consequently

FIG. 1.

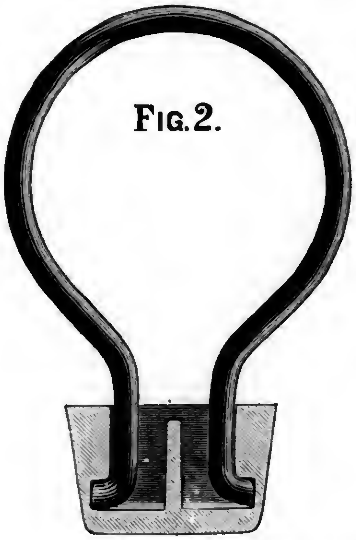


FIG. 2.

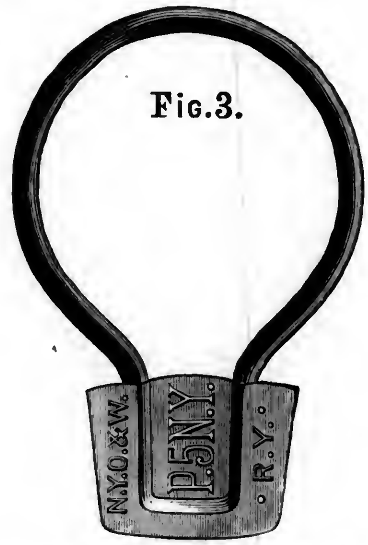


FIG. 3.

new seals have been devised and offered to the public, with a view to overcoming the objections inherent in the old patterns.

The engravings herewith, figs. 1, 2, and 3, represent one of these new forms which has recently been brought out. It has the merit of being strong and simple, and practically serves as a lock as well as a seal. It consists of a strong bail of steel wire bent into the shape shown in fig. 1, in which the seal is represented as detached from the wire. In fig. 2 the seal is shown in section in its relation to the wire before it is compressed, and fig. 3 shows it after being compressed in the wire. An ingenious press is furnished for these seals, which has a lever and eccentric for squeezing the seals between dies so as to fit the wire and receive the letters or other devices cut on the dies. The seals are made of a composition metal considerably stronger than lead, and which requires more pressure to make it "flow" than a softer metal would. For this reason a very powerful press is required, which the manufacturers furnish with the seals. It is made with a cavity into which the seals fit accurately, so that every one is an exact duplicate of every other, just as coins are duplicates, so that any deviations of the seals from each other are readily detected by ordinary inspection. For further information the manufacturer, A. B. Schofield, may be addressed at 170 Broadway, New York.

Splice-Bars.

MESSRS. MORRIS SELLERS & CO. during the past year have doubled the capacity of the Chicago Splice-Bar Mill, in which they manufacture the celebrated "Samson" bar.

The place where the fracture occurs in 99 out of 100 breakages of splice-bars or fish-plates is in the middle, where the two rails join. It is only a common-sense deduction from this fact that the bars should be made strongest at that point. In the Samson bar this deduction has been put into practice by making the bars thicker in the middle than at the ends, which means that the metal is put "where it will do the most good." These bars are at least a half inch thicker in the middle than ordinary bars, and, owing to the way in which the metal is distributed, they cost no more than ordinary bars.

The firm referred to has issued a circular giving a list of over 150 railroads on which more than 8,000,000 of these bars are now in use. In one instance it is reported from a road having 4,000 miles of track, half of which was laid with Samson bars, that only 1 per cent. of the breakages of splice-bars were of that pattern.

Manufacturing Notes.

THE Indianapolis Hydraulic Jack Company recently furnished a number of its jacks to the Chicago, St. Louis & Pittsburgh Railroad.

THE Miller Forge Company, Limited, in Pittsburgh is making an iron shaft 34 ft. long and 16 in. diameter for the tow-boat *W. W. O'Neill.*

THE Swindell Construction Company in Pittsburgh has taken orders since January for a number of steel plants, furnaces, and gas producers for steel works.

THE Brooks Locomotive Works in Dunkirk, N. Y., recently received orders for eight heavy mogul engines, seven passenger, and three switching engines for the Cleveland & Canton road.

THE Baltimore & Ohio Railroad is building at its Mount Clare shops, Baltimore, a number of consolidation engines of increased power and weight, for service on the mountain grades. Total weight of engines in working order, 124,300 lbs.; cylinders, 20×26 in.; driving wheels, 50 in. diameter.

H. K. PORTER & CO. in Pittsburgh lately shipped a small locomotive to the United States Government for improving the Columbia River in Oregon, and have now street motors under way for Tacoma, Milwaukee, St. Louis, and other places. These motors are enclosed to resemble street cars, and are smokeless and noiseless. The firm is also building a number of coke oven and furnace locomotives for Southern companies, and logging locomotives for Louisiana. One locomotive, just shipped to a copper company in Arizona, is for only 20 in. gauge of track, and with cylinders 9½ in. diameter. The firm also has locomotives and motors ready for shipment for the Croton Aqueduct, New York, Arkansas, California, Florida, and and Alabama.

THE American Brake Company, of St. Louis, has recently placed its driver-brake on two of the Pennsylvania Company's "Class S" heavy freight locomotives, at the Fort Wayne shops. These brakes are now in regular service and give satisfaction. No special tests of their working have been made.

THE City of Chicago has awarded a contract to Edward P. Allis & Co., of Milwaukee, Wis., for five new triple-expansion condensing pumping engines of the same design as the new West Side plant, recently built by that firm for the City of Milwaukee. These were the first engines of their type constructed in the country. The capacity of the Chicago engines will be 15,000,000 gallons of water per 24 hours each. The total cost of these pumping engines will be about $400,000.

THE Harlan & Hollingsworth Company in Wilmington, Del., has just delivered 15 sleeping cars, 5 parlor cars, and 5 day coaches to the Baltimore & Ohio; 4 day coaches and 4 eight-wheel cabooses to the Mexican Central; 5 day coaches to the San Francisco & North Pacific; 1 day coach and 1 baggage car to the Lackawanna & Pittsburgh. Among other work under construction in the shops are 7 sleeping cars (16 sections), 3 of them for the Boston & Albany, and 4 for the New York, New Haven & Hartford Railroad.

ORDERS have recently been received by Riehle Brothers, of the Philadelphia Scale & Testing Machine Works, for 1,000-lbs. cement testing machines for the City Engineer, Buffalo, N. Y.; Vanderbilt University, Nashville, Tenn., and others; also for a 2,000-lbs. cement testing machine for the United States Military Academy at West Point. Orders for larger testing machines include a 5,000-lbs. transverse testing machine for the Decatur (Ala.) Car Wheel Company; a 50,000-lbs. spring testing machine for the Atkinson Car Spring Company, Chicago; a 50,000-lbs. Vanderbilt machine for the Farrell Foundry & Machine Company, Ansonia, Conn.; and a screw-power Harvard testing machine of 100,000 lbs. capacity for the Baltimore & Ohio Railroad. Orders have also been received for pipe-testing machines, cloth-testers, and a number of heavy mine and rolling mill scales.

A New Automatic Cut-Off Engine.

THE accompanying illustrations represent a new automatic cut-off engine built by the Erie City Iron Works, at Erie, Pa. The object of the builders has been to produce an engine which will give close practical regulation, with changes either in load or in steam pressure, and at the same time shall be simple and without undue complication of parts. These engines are built from entirely new designs and patterns, and are so made that working parts can be duplicated and new parts furnished at any time. The cylinders are jacketed, the reciprocating parts well balanced, and care has been taken to make the work as durable as possible.

The engine bed is in form somewhat similar to the Porter type, and is so made as to bring the centers of the moving parts as low down as possible. The center of the cylinder is in line with the center of the crank-shaft. At the crank end the bed is made very wide, securing plenty of bearing for the foundation, giving abundant room for journals, and making the bed very strong.

The cylinder and steam chest are cast together and are shown in section in fig. 2, fig. 1 being a general view of the engine. The steam ports are very short, and the exhaust passage has an area fully equal to that of the exhaust-pipe; the arrangement is such that a quick exit is given to the exhaust steam. The steam ports are covered by plates giving easy access for inspection without removing the valves or steam chest covers. The valves are piston valves of a very simple pattern, being formed merely of a thin ring of proper width made by a special method, so that when it is in position in the steam chest it is a perfect fit. The ring being sprung takes up its wear and keeps tight. The ring being circular is balanced, and live steam is admitted only between the two inside shoulders of the valve, which, being of equal area, balance each other. A small hole is drilled in the port side of the ring permitting live steam to enter only when the valve is admitting steam to the cylinder. The object of this is to counteract the tendency of the valve to close up when it is uncovered by the steam port, as the live steam entering the small hole acts on the inside of the valve ring, pressing it outward. The port is an annular space around the valve opening into the cylinder, and, the valve seat being arranged so that when the valve is cutting off at about one-eighth stroke, it works over the seat at each stroke, there is no chance for forming shoulders. The valve stem is supported at both ends as shown.

The crank shafts of these engines are forged solid in the bell part, then slotted, and the pin turned up out of the solid metal. The crank pin is equal in diameter to the shaft. The counter balances are rigidly fastened to the crank and are of sufficient size. The connecting rods are of forged iron, and the adjusting keys are so arranged that the length of the rod can be maintained at all times; they are secured by steel set screws. The cross-head is of cast iron sufficiently heavy, and the cross-head pins are turned up by a special machine.

The piston packing is made with three sprung rings fitted and turned to give the best protection against leakage of steam. With the piston, as with all the working parts of these engines, the object has been to give large wearing surfaces wherever possible. The piston rod is of steel, and is shrunk on to the head and then riveted over. The connection between the piston rod and cross-head is made by a heavy forged steel key.

The valve stem is made of steel and is fitted outside the steam

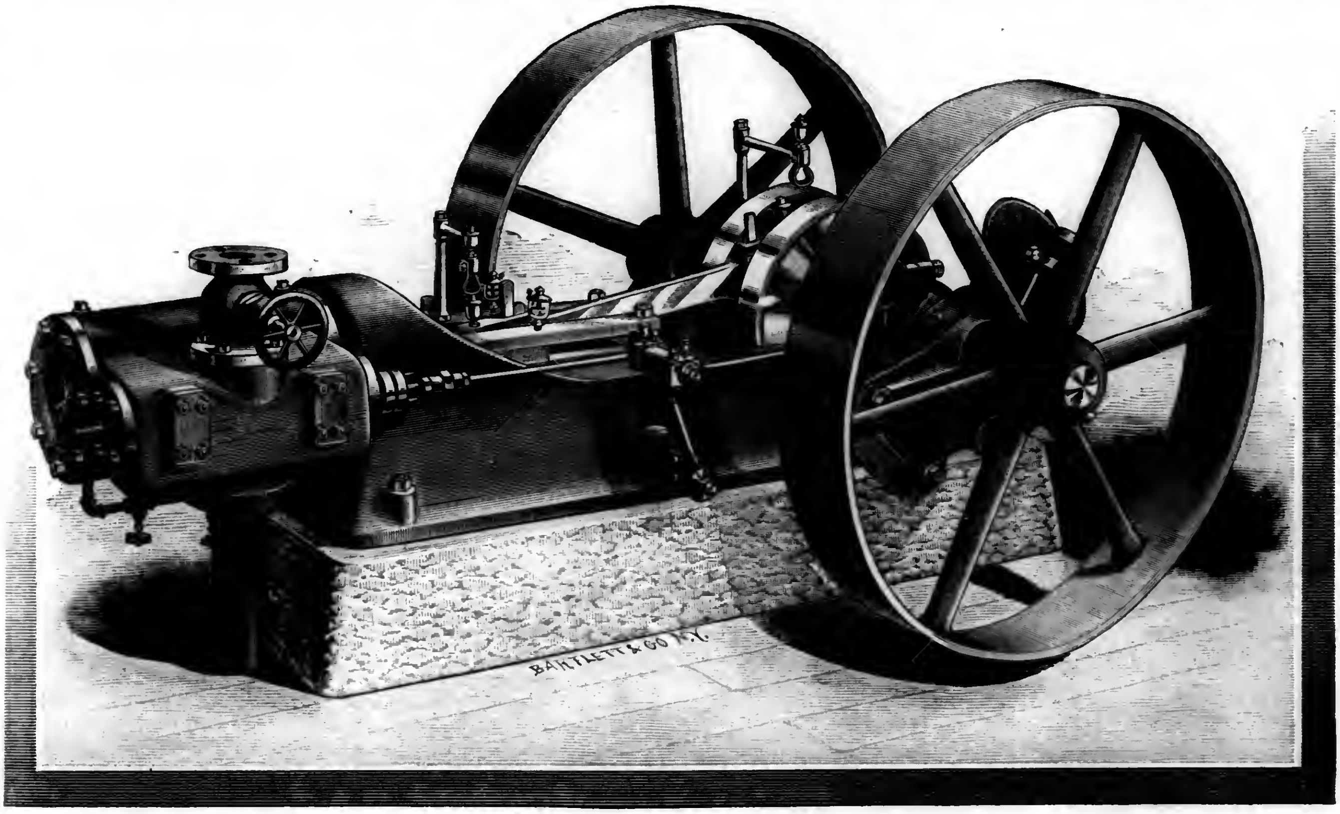


Fig. 1.

NEW AUTOMATIC CUT-OFF ENGINE.

Built by the Erie City Iron Works, Erie, Pa.

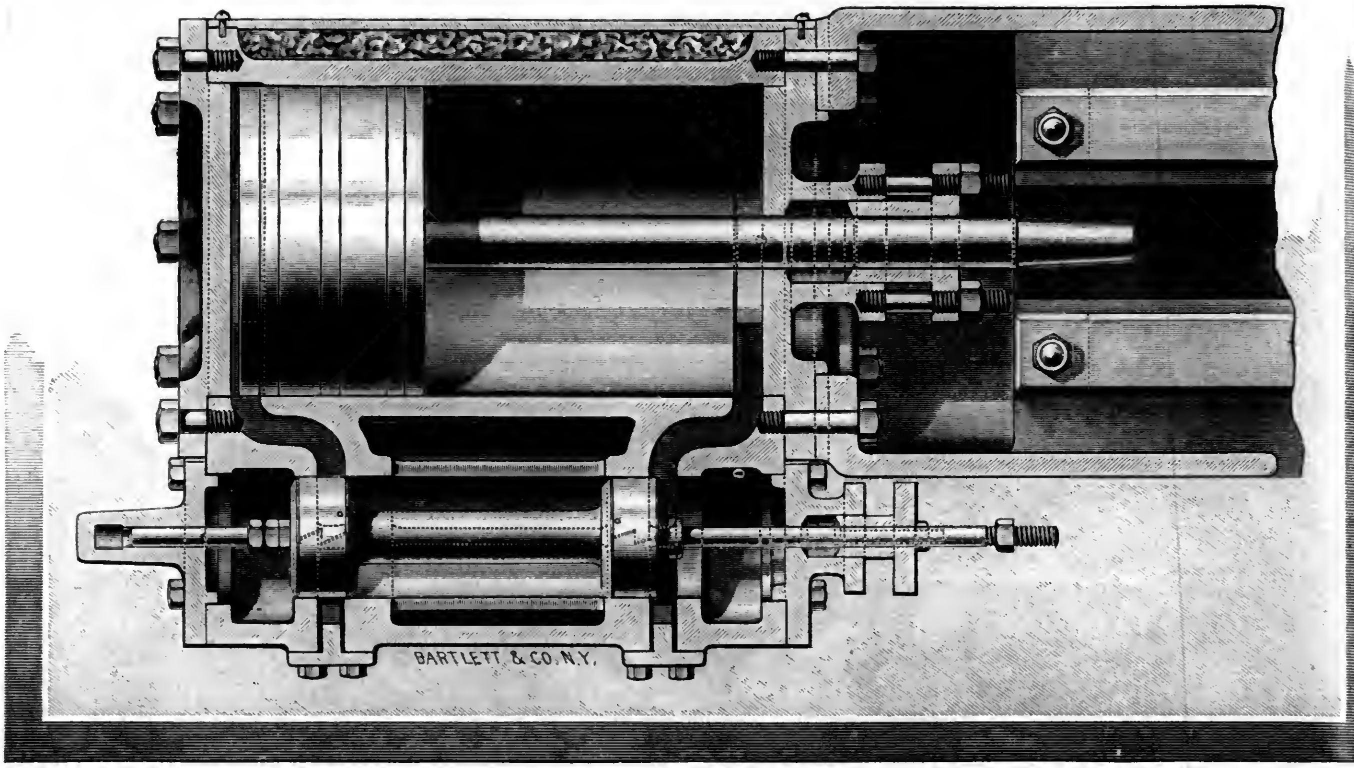


Fig. 2.

chest with a right-and-left-hand screwed connection and jam nuts, so that the valve can be easily adjusted. The practice in this shop is to test all engines and adjust the valves properly before they are sent out. The rocker has large bearings and the connections with the valve stem are so arranged that they can be adjusted.

One of the most essential parts of these engines is the governor, which is of the type known as shaft or isochronal governors, but is made on an entirely new plan; it is simple in construction and has few parts. As shown in fig. 3 it is independent of the driving pulley, and allows a change to be made in the latter, when required, without affecting its adjustment.

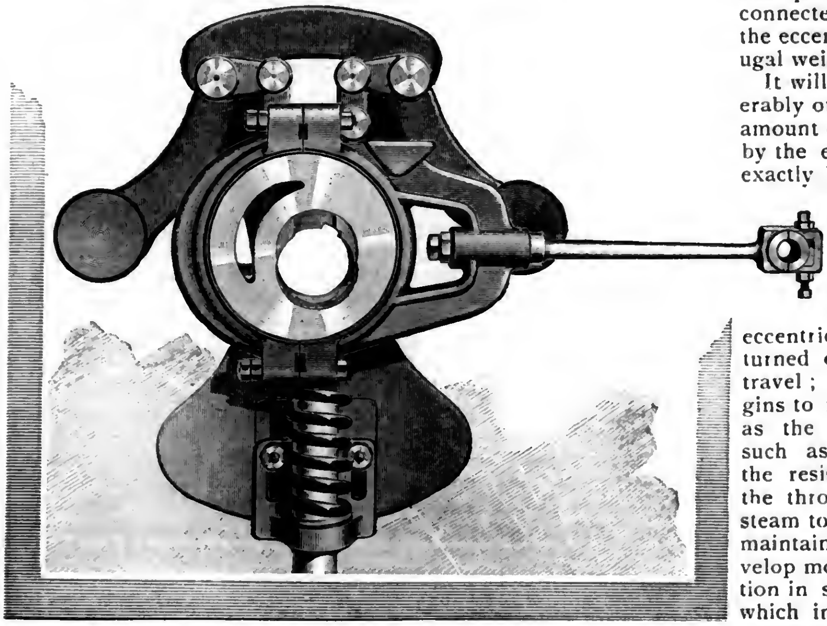


Fig. 3.

The main frame of the governor has a guide cast on the hub, next to the eccentric, to receive the corresponding slide which is cast on the latter. This slide is extended at the top and forms an arm to receive the links connecting the bell-crank levers to the eccentric. The latter has a slotted hole, through which the shaft passes, and permits the eccentric to be moved across the shaft in a straight line, altering the travel of the valve to correspond with the work required of the engine without changing the lead. The slide on the eccentric is also extended on the lower side, and forms a guide which passes through a movable plate on the governor frame, which has an extension to receive the guide. This forms a secondary guide for directing the travel of the eccentric across the shaft. A compression spring is placed around this guide, and has for its lower seat the projection on the movable plate through which the guide passes. Its upper seat is fixed, and is formed by a shoulder on the guide on the eccentric.

The bell-crank lever weights are fulcrumed on the governor frame at two projections on the upper side through which pass steel pins forming the fulcrums. One end of each bell-crank is connected by steel pins to the link attached to the upper end of the eccentric; the other end of each bell-crank forms the centrifugal weight.

It will be noticed that the arms of the bell-cranks are considerably out of the perpendicular; this gives the weights a certain amount of gravity, which is proportional to the gravity exerted by the eccentric when in the vertical position, as shown, and exactly balances the eccentric and parts. This effect is also entirely independent of the centrifugal force exerted by the weights, and, owing to the balancing of the parts, the engine is found to be very quiet when running.

The working of the governor may be described as follows: When the engine is idle the weights and eccentric have such a position that should the engine be turned over by hand, the valve would be at its greatest travel; as soon as steam is admitted, and the engine begins to revolve, the weights attain increased centrifugal force as the engine runs faster and faster, until the speed is such as to give enough force at the weights to overcome the resistance of the springs, when they fly out and alter the throw of the eccentric, and thus cut off the supply of steam to the amount required to perform the exact work and maintain the same speed. When the engine is required to develop more power by increased load, there is a slight retardation in speed, dependent upon the amount of increased load, which instantly decreases the centrifugal force and permits the spring to adjust the eccentric to the required travel of the valve to develop the proper power and maintain the correct speed. When the load is diminished the action is just reversed. The speed of the engine may be altered somewhat from that at which the engine is originally intended to run, by compressing the spring by means of the movable plate, if greater speed is required, and by reducing the compression by the same means if less speed is required. The limit of change in speed should not exceed 5 per cent.; when more is required a new spring must be used, and the weights should probably be changed also.

Figs. 4 and 5 show two indicator cards, the particulars of which are as follows:

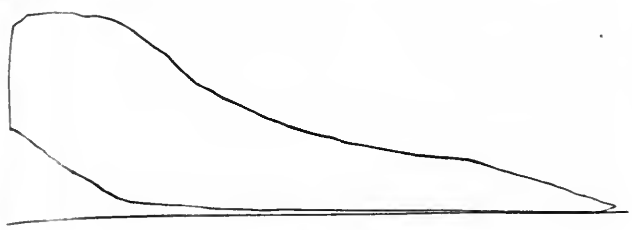


Figure 4:

Size of cylinder	10 by 12 in.
Revolutions per minute	260
Scale	60
Mean effective pressure	25.1 lbs.
Indicated horse-power	31.00

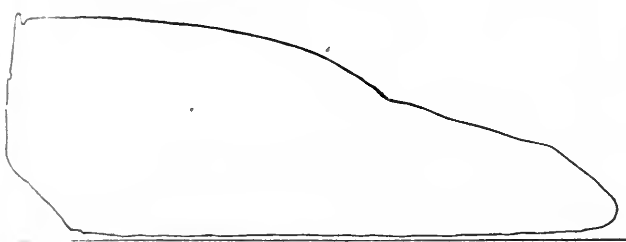


Figure 5:

Size of cylinder	10 by 12 in.
Revolutions per minute	260
Scale	60
Mean effective pressure	44.8 lbs.
Indicated horse-power	55.44

These cards were taken from an engine of the pattern described, to which steam was delivered through a pipe 250 ft. long.

Proceedings of Societies.

American Society of Civil Engineers.

A REGULAR meeting was held at the Society's House in New York, March 21. The Secretary announced the death of Squire Whipple, and, after some remarks, it was ordered that a committee be appointed to prepare a memoir.

A circular communication on Increasing the Durability of Timber, from the Forestry Division of the U. S. Department of Agriculture, was read.

The Secretary read a paper by Edward Prince upon a 30-in. wooden conduit designed and constructed for the Quincy, Ill., Water-Works. The conduit connected the iron water-pipe on shore at the pumping-station with the point of supply at a crib 1,480 ft. away in the Mississippi River, and was built in three sections of 540, 548, and 400 ft., towed out to position, launched, then connected, ballasted, and sunk to position.

The Secretary was requested to ask Mr. Prince for further data than was embodied in the very brief description. It was thought that in some parts of the Mississippi the current would scour underneath the conduit and soon let it down many feet, effectually protecting it from navigation, ice, etc., and inquiry was made whether the increased length that would be required for the elongation of the conduit had been provided for.

Mr. Emil Kuichling presented a written discussion on Mr. McMath's paper on Sewers, which was further discussed by Mr. Hering.

A REGULAR meeting was held in New York, April 4. The Secretary announced the deaths of George W. Cass, Charles Latimer, and William A. G. Emonts, and committees to prepare memoirs were ordered.

Mr. J. F. Flagg presented a written discussion on the Flow of Sap in Trees, by J. F. Flagg.

Mr. R. K. Wright, Jr., lately Section Engineer on the Panama Canal, made some informal statements describing the condition and administration of the work; replies were offered by Messrs. Appleton and Colné, and some discussion by members followed.

The Tellers announced the following elections:

Members: William Coulman Ambrose, San Francisco, Cal.; Francis Webster Blackford, Jr., Butte, Mont.; Howard Breen, Pittsburgh, Pa.; Edward Carlos Carter, Chicago, Ill.; John Joseph Donovan, Helena, Mont.; Frank Louis Fuller, Boston, Mass.; Bruce F. House, Denver, Col.; James MacFarlane, Anaconda, Mont.; Charles Clemons Rose, Scranton, Pa.; Horace Edward Stevens; Charles Frederick Stowell, Albany, N. Y.; Arthur Newell Talbot, Champaign, Ill.; Charles Chancellor Wentworth, Roanoke, Va.

Associate: George Henry Crafts, Atlanta, Ga.

Juniors: William George Clark, Toledo, O.; Arthur Leland Cornell, Tarrytown, N. Y.; Edward Berton Kent, Milwaukee, Wis.; William Willis Penney, St. Louis, Mo.; Louis Lincoln Tribus, New York; Harry R. Wheeler, Sing Sing, N. Y.

Engineers' Club of Philadelphia.

A REGULAR meeting was held at the House in Philadelphia, March 17, Vice-President John T. Boyd in the chair; 30 members and 6 visitors present.

Mr. A. Marichal read a paper upon the Testing of Cements, calling the attention of the Club to the waste of money resulting from the incomplete knowledge of the properties of cements. "Some engineers spend many hundred dollars to test their cement; yet the mortar used in their works is not worth a penny."

Mr. Marichal asked for the appointment of a committee of five who would recommend a *practical method of testing cements* and present it to the Club for its approval, which, on motion, was ordered.

The Secretary presented, for Mr. Frederic H. Robinson, a complete description of the Manufacture of Gunpowder.

Professor J. W. Redway followed with a discussion of the chemical reaction which takes place during the explosion of gunpowder and other explosives, giving a summary of results of experiments and investigations by himself and others.

Mr. L. F. Rondinella presented a paper upon Incandescent Electric Lighting, giving tables, formulæ, and calculations, for the determination of the relative commercial values of lamps of higher efficiency and shorter life, with those of lower efficiency and longer life.

AT the regular meeting of April 7, the Secretary presented, for Mr. Frederic H. Robinson, a description of the Electric Street Railroad, at Wilmington, Del.

Mr. William H. Robinson presented an illustrated paper upon Rope or Cable as a Transmitter of Power.

The Secretary presented, for Mr. C. A. Preston, a description of the Effect of Gases, etc., from Stacks, upon Iron, illustrated by a drawing of the Charles Street Bridge, over the Northern Central tracks at Union Station, Baltimore, Md., and by a very complete and interesting set of specimens of iron from the bridge.

Mr. Herbert Bamber presented notes upon Two Experiments with Cement Mortar.

Mr. Howard Murphy presented a diagram showing the results of Watertown Arsenal tests of the crushing strength of Potomac Red Sandstone and other building stones, bricks, and brick masonry.

Mr. Edward Hurst Brown mentioned that the reason the Potomac Red Sandstone was not more used for architectural purposes was that, while of a beautiful color, owing to its extreme hardness it was very difficult to dress, and also that very often in an apparently perfect stone a flaw would develop in dressing the face which would render it useless for facing stone.

A communication by Mr. G. Y. Wisner, C.E., for years connected with the Lake Survey, entitled Physical Phenomena of Lake Harbors, was submitted by title. It shows that the progressive movement of sandy spits is attributable to the resultant waves and currents produced by the periodic oscillations of the lake surface, and that the effects are similar to those produced by the flood-tide on the Atlantic Coast, as explained by Professor L. M. Haupt in his paper on the Physical Phenomena of Harbor Entrances.

Boston Society of Civil Engineers.

THE annual meeting was held March 21 in the parlors of Young's Hotel. After listening to the annual reports of the Governing Committee and the special committees, balloting was

had for election of officers for the coming year, with the following results:

President, D. Fitz Gerald; Vice-President, F. P. Stearns; Secretary, S. E. Tinkham; Treasurer, Henry Manley; Librarian, H. D. Woods.

After transacting some other business matters, the meeting adjourned to the large dining-hall to partake of the annual dinner.

Engineers' Society of Western Pennsylvania.

THE regular monthly meeting was held in Pittsburgh, March 20.

Mr. J. F. Bray opened the discussion on his paper on the Welding of Steel Tubes, which was read at the January meeting. The discussion was continued by Messrs. Barnes, Metcalf, and Koch, and Captain Hunt.

Professor F. C. Blake then read a paper on the Electrolytic Separation of Gold and Silver.

A REGULAR meeting was held in Pittsburgh, April 17, at which 56 members and 4 visitors were present. George H. Barbour and Louis B. Fulton were elected members.

A paper on Aluminum was read by Phineas Barnes. In the discussion on this paper A. E. Hunt, William Metcalf, T. P. Roberts, J. A. Brashear, and several other members joined.

Western Society of Engineers.

A REGULAR meeting was held in Chicago, April 3. The following members were elected: Edward B. Meatyard, Geneva Lake, Wis.; Paul K. Richter, Daniel A. With, Chicago.

The Committee on Specifications for Highway Bridges was not ready to submit a formal report. The subject was, however, taken up and discussed at some length on the line of the last meeting.

The Committee on National Public Works reported the receipt from the Council of Engineering Societies of a copy of the Cullom bill for the establishment of a Bureau of Harbors and Water-ways, and memorial in its favor. The Committee reported resolutions in favor of the bill, which were adopted. The Committee also reported that an assessment or contributions for the work of the Council was desired.

Engineers' Club of St. Louis.

A REGULAR meeting was held in St. Louis, March 21. Messrs. William S. Henry and John B. Myers were elected members.

Mr. S. F. Burnet then read a paper on Cements and Mortar. He gave some practical hints on mixing and using same; also how specifications should read and tests be made. He exhibited specimens and gave results of tests. Some information on sand, water, and lime was given. The damaging effects of freezing were shown. Professor Johnson and Messrs. Bruner, Wheeler, and Russell took part in the discussion.

The Secretary then read a short paper by E. L. Corthell in review of one by Robert Moore on Interoceanic Ship Transfer, read before the Club March 2, 1887. The criticisms of Mr. Moore on the floating pontoon, the wheel load, comparative economy and capacity of carriage were reviewed to show the practicability of the design. Mr. Moore replied at some length.

Professor Johnson called attention to some bars of iron which had been broken in a testing machine after having been strained beyond their elastic limit and then allowed to rest. The results were: After a rest of one day, an increase of strength of 16 per cent. was shown; seven days, 22 per cent.; sixteen days, 26 per cent.

Mr. Bruner called attention to a remarkable case of filtering water through an ordinary brick wall. Professor Nipher reported the results of some experiments on leakage of gases through brick walls.

A REGULAR meeting was held in St. Louis, April 4. Mr. Russell Parker was elected a member. Resolutions in relation to the death of Frederick Schickle were reported and adopted.

The President presented a communication from L. E. Cooley, President of the Council of Engineering Societies on National Public Works, on the subject of the Reorganization of National Public Works. On motion it was made the special order for the next meeting, April 18.

The Secretary then read a paper on Railroad Location; Field Practice in the West, by Willard Beahan. The author explained the difficulties to be overcome, and the most common methods employed. He also gave his own method, which he had used largely, with very satisfactory results. The paper was discussed by Professor Johnson and Messrs. Wheeler, Seddon, Moore, Bouton, and Clark. There was considerable diversity of opinion as to the best method to follow, which in every case must depend upon the character of the country to be traversed.

Professor Nipher explained to the Club a calorimeter he had prepared for the purpose of determining the heat value of fuels. It was a quick method and gave accurate results. The apparatus was shown and a test made. After some general discussion of Western fuels, the meeting adjourned.

Engineers' Club of Kansas City.

THE regular meeting was held in Kansas City, April 2. A letter from Mr. L. E. Cooley to the Committee on National Public Works was presented, requesting that the Club be represented at a meeting of delegates to be held in Washington, April 9. It was ordered that the Executive Committee appoint a delegate, and that his expenses be paid by the Club.

Contributions to the discussion of the evening were read from C. E. H. Campbell, C. S. Burr, Charles L. Strobel, A. J. Tullock, and Professor George L. Vose. The reading of other discussions was postponed until the next meeting.

The following gentlemen were declared elected members: Charles C. Silman, Robert Gillham, Charles S. Brown, James H. Grove, E. J. Remillon, and Frank Allen. Associate Members: J. B. Hodgdon and George K. Musselman.

New England Railroad Club.

THE monthly meeting was held in Boston, April 11, President Lauder in the chair. The subject for discussion was Steam Heating of Passenger Cars.

Professor Lanza, of the Massachusetts Institute of Technology, opened the discussion. He said that there had been widely diverse opinions expressed regarding the heating of passenger trains by steam from the engine. Some say that sufficient steam can be taken from the engine without its loss being noticed, while others declare that the engine cannot make time if the steam for heating is taken from it. He stated that Mr. Lauder, of the Old Colony, had put the boat train of four cars at his disposal for the purpose of experiments, and that the experiments showed plainly that neither of the extreme statements is correct; neither is the loss of the amount of steam used inappreciable, nor is the engine unable to make time. In response to a question, he said that 40 lbs. pressure of steam was used in all the experiments.

The Gold system of heating was then explained by Mr. Gold and Mr. Bell, and Mr. Temple described the automatic arrangement for regulating the temperature of cars of the Johnson Electric Service Company, as tried on the Chicago, Milwaukee & St. Paul Railroad.

Mr. McElroy, Mr. Sewell, and Mr. Chase described their respective couplings for steam-pipes. Reducing valves and traps were last considered, and several were described.

New York Railroad Club.

THE regular monthly meeting was held in New York, April 19, with a large attendance of railroad men and others.

The subject of car heating was discussed at much length, the merits of different systems being set forth by their representatives.

Automatic Car Couplers had been announced as a second subject, but was postponed to the next meeting.

Western Railway Club.

THE regular monthly meeting was held in Chicago, March 21.

Mr. J. N. Barr read a paper advocating the use of six-wheel trucks for freight cars of 60,000 lbs. capacity. This, he believed, would be better than to increase the size of the axles.

The paper was discussed by Messrs. Verbryck, Smith, Sinclair, Rhodes, Hickey, Cooke, Schroyer, and Snow. Mr. Rhodes presented a number of facts based on experience in the Burlington brake tests.

The Secretary read a paper by Mr. John Mackenzie, on Wear of Locomotive Tires, in which a number of diagrams taken from worn tires were given. This paper was discussed by Messrs. Rhodes, Cooke, Smart, Gibbs, and Foster.

The subject of Car Axles was postponed to the next meeting.

A National Organization of Railroad Accounting Officers.

At the recent meeting of railroad accountants held in Washington, a motion was unanimously adopted providing for the appointment of a committee of 15 to consider the desirability of forming a National Organization of Railway Accounting Officers similar to that of the officials of other departments of railroads. It was provided that this committee should be appointed by the Chairman of the Washington convention (Mr. Kirkman), who is also to be Chairman of the committee.

Association of North American Railroad Superintendents.

The annual meeting was held in New York, April 9. Reports were received from the Committees on Roadway, on Frogs and on Transportation, and the usual miscellaneous business was transacted. On the following day the members took an excursion over the Lehigh Valley road to see the operation of the train-telegraph system.

The following officers were elected for the ensuing year: President, C. S. Gadsden, Charleston & Savannah; First Vice-President, L. W. Palmer, New York & New England; Second Vice-President, J. B. Morford, Michigan Central; Third Vice-President, T. W. Burrows, Indianapolis & St. Louis; Secretary, Waterman Stone, Providence, Warren & Bristol; Assistant Secretary, C. A. Hammond, Boston, Revere Beach & Lynn; Treasurer, R. M. Sully, Richmond & Petersburg; Executive Committee, C. W. Bradley, West Shore; W. F. Stark, Dayton & Union; R. G. Fleming, Savannah, Florida & Western; D. W. Sanborn, Boston & Maine, and the President.

General Time Convention.

The spring meeting was held in New York, April 11. The summer schedules for through trains were adopted, and May 13 was fixed as the date when changes are to be made.

The Committee on the Transmission of Accurate Time was continued, and in this connection Commander Allen D. Brown, of the National Observatory at Washington, addressed the meeting on the manner in which the official time was sent out.

The report of the Committee on Car Mileage and Per Diem Rates was made, recommending the adoption of the mixed mileage and per diem system of charges for the use of cars. The report was laid over until the October meeting.

Officers for the ensuing year were elected as follows: President, H. S. Haines, Savannah, Florida & Western; First Vice-President, J. M. Toucey, New York Central & Hudson River; Second Vice-President, D. J. Chase, Atchison, Topeka & Santa Fé; Secretary, W. F. Allen, *Official Railway Guide*. Executive Committee, H. B. Stone, Chicago, Burlington & Quincy; J. W. Thomas, Nashville, Chattanooga & St. Louis; James McCrea, Pennsylvania; C. W. Bradley, West Shore; E. T. D. Myers, Richmond, Fredericksburg & Potomac, and John Adams, Fitchburg. The Convention adjourned to meet next October.

American Society of Mechanical Engineers.

Mr. F. R. Hutton, Secretary, has issued a circular announcing the seventeenth meeting, which will convene in the city of Nashville, Tenn., on Tuesday, May 8, at 8 P.M., and will adjourn on Friday of that same week.

The Headquarters and Secretary's office will be in the Maxwell House, corner of Church and Cherry streets, and as many as possible are urged to stay at the same house, for the sake of the advantages, social and professional, of this course.

The exact details of allotment of sessions, etc., will be given on the Docket, which will also give the order of presentation of papers, and which will be distributed in Headquarters as a condensed programme.

The Secretary calls attention to the rules for the presentation of papers, and requests all members to inform him whether they will attend the meeting. Special rates can be obtained on the railroads for members.

American Institute of Mining Engineers.

Professor R. W. Raymond, Secretary, has issued from his office, No. 13 Burling Slip, New York, a circular containing the following announcements:

1. The Fifty-first Meeting of the Institute will be held at Birmingham, Ala., beginning Tuesday evening, May 15, 1888. Communications concerning the meeting may be addressed to Mr. Kenneth Robertson, at that place. Further details concerning it will be issued in a subsequent circular.

2. No special railroad rates for members attending this meeting have been arranged. The number of members willing to accept the conditions now universally imposed on such arrangements (the immediate return without stops by the same route, etc.) has proved to be so small on former occasions as to give us no basis for negotiation with the railroad companies. The general facilities now offered by different lines in the way of tourists' tickets are not less favorable, and are more simple and elastic than anything which it is practicable to secure by special application.

3. It is expected that, after the sessions at Birmingham, the Institute will visit Anniston, Ala., and the interesting mines, furnaces, and shops in that vicinity. Since the accommodations for ladies at Birmingham are limited, it is suggested that ladies accompanying members should remain at the beautiful and commodious Anniston Inn during the Birmingham sessions.

4. Notices of papers to be presented at this meeting should be sent as early as possible to the Secretary, accompanied with either the papers themselves or full accounts of their character, length, illustrations, etc.

Master Car-Builders' Association.

The following circulars have been issued by the Secretary from his office, No. 45 Broadway, New York:

BEST FORM OF DOOR HANGINGS, INCLUDING GRAIN DOORS.

The undersigned committee, appointed to consider the above subject and report at the Convention to be held in June, 1888, desire to obtain replies to the following questions:

1. What kind of side door and door hangings are you using on freight cars?
2. What grain doors are you using, and are you satisfied with the workings of same?
3. Are you using any patent doors and hangings, and what is your opinion of same?
4. What is your opinion of a flush door, and what kind have you used?

Please address replies to this circular to E. W. Grieves, Baltimore & Ohio Railroad, Mt. Clare, Baltimore, Md.

E. W. Grieves,
John P. Levan,
John Voorhees.

STANDARD AXLE FOR CARS OF 60,000 LBS. CAPACITY.

Since the last Annual Convention of the Association, the form and dimensions of a proposed standard axle were submitted to letter ballot for adoption, and failed to receive two-thirds of the votes cast, which are required to adopt a standard. As the subject is an important one and is likely to come up for consideration again, it has been thought by the Executive Committee that it would be well to get the views of the members of the Association before the meeting of the next convention, in order to be prepared to take some action at that time, which would be acceptable to a majority of the members. You are, therefore, requested to fill out the dimensions which you would recommend for a standard axle for cars of 60,000 lbs. capacity, on the accompanying engraving, and return to the Secretary with your signature appended.

M. N. Forney, Secretary,
45 Broadway, New York.

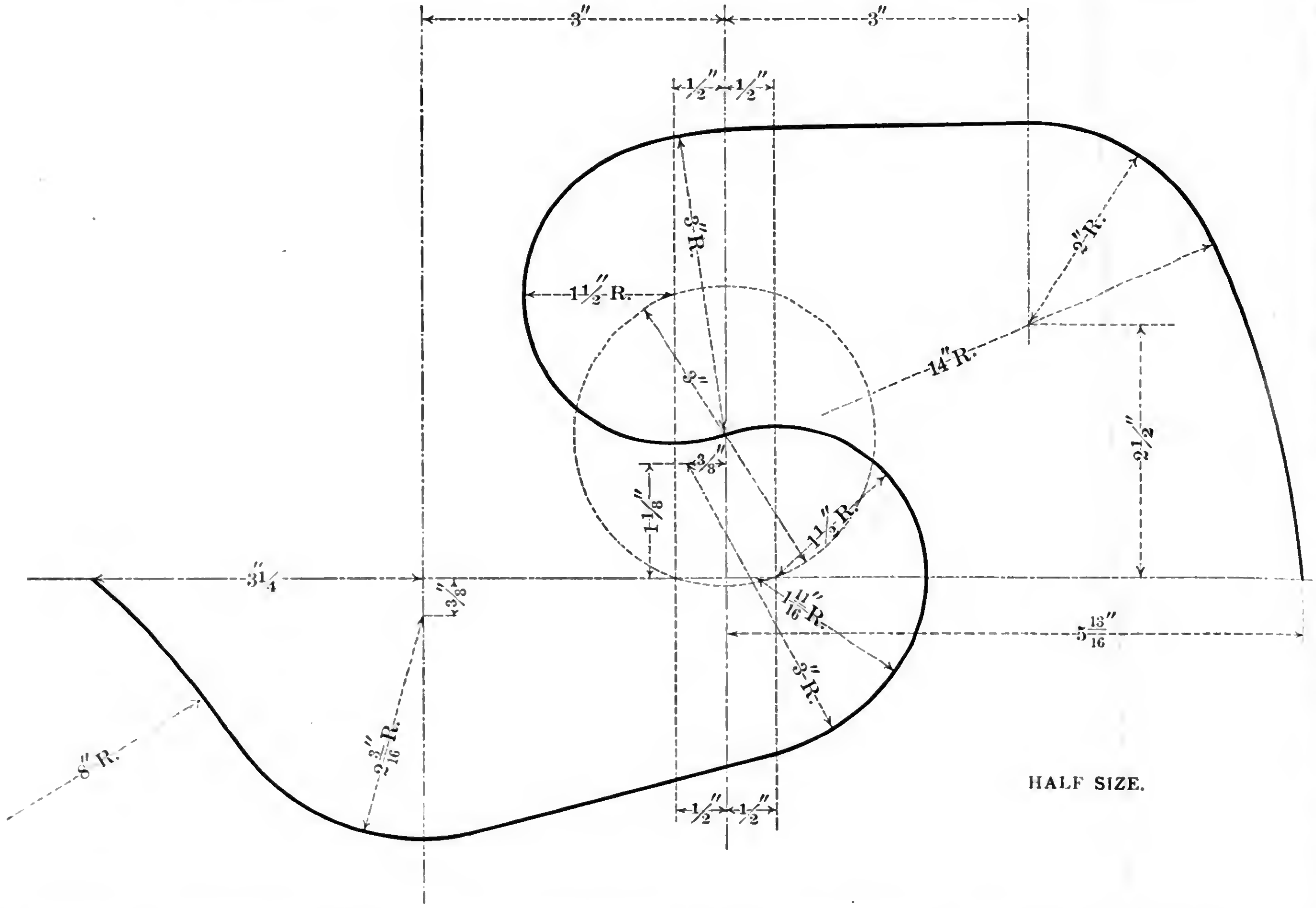
(A sketch of axle, with blanks left for the figures to be filled in, is appended to this circular.)

STANDARDS AND APPLIANCES FOR THE SAFETY OF TRAINMEN.

The Railroad Commissioners of the State of New York report that during the year ending September 30, 1887, there were 199

FORM OF CONTOUR LINES

for M. C. B. Automatic Car Couplers, as established by the Executive Commission of the Master Car-Builders' Association.



railroad employés killed and 896 more or less severely injured, in the performance of their duties. These accidents are classified as follows :

	Killed.	Injured.
Fell from train, engine, or cars, or getting on or off trains.	48	152
Striking low bridges, switches, tunnels, etc.	8	9
Coupling or uncoupling cars	20	437
Walking or being on track	102	88
Catching foot in frog or between rails	4	7
Derailment	1	19
Collisions	6	40
Other causes	10	144
Total	199	896

According to *Poor's Manual*, the number of locomotives owned by railroads in the State of New York in 1886 was 2,722, and in the whole country 26,415. It will be quite safe to say that there were ten times as many locomotives in the whole country as there were in New York State during the period covered by the Railroad Commissioners' report. If the average number of persons killed and injured per locomotive is the same elsewhere, the number of casualties to railroad employés in the whole country would be ten times the above figures, or a total in round numbers of 2,000 killed and 9,000 injured.

No pretence is made that this estimate gives the number of employés killed and injured with anything more than an approximation to accuracy. It must be remembered, though, that whatever errors there may be in the reports of accidents to the Railroad Commissioners, and of the number of locomotives in the country, are errors of omission, and that probably both the number of accidents and of locomotives are greater than reported, which would make the above estimate too low rather than too high. Nevertheless, with any reasonable deduction the record of frightful suffering, pain, and sorrow will be more than sufficient to emphasize the following inquiries, the aim of which is to elicit information that will indicate how the number of such accidents may be diminished.

All railroad officers and employés, whether members of the Master Car-Builders' Association or not, are therefore requested to answer the following questions :

1. What defects are there in the present construction of cars and locomotives which cause accidents to railroad employés by falling from trains, engines, or cars, or of accidents in getting on or off trains ?
2. What changes could be made in cars or locomotives which would diminish the number of such accidents ?
3. What kind of couplers and dead-blocks are the most dangerous to employés in coupling cars ?
4. What kind of coupler and dead-blocks do you think is the least dangerous to employés ?
5. Has the introduction of automatic couplers thus far lessened the danger of coupling cars ?
6. Would the general introduction of automatic couplers in your opinion diminish the danger of coupling cars ?
7. Can you suggest any way of lessening the number of accidents to employés from "walking or being on the track" ?
8. How can employés be prevented from "catching their feet in frogs or between rails" ?
9. In what way may any other kinds of accidents to employés be prevented or the number lessened ?

All railroad officers and employés who see this circular are earnestly solicited to answer it, and thus add the weight of their testimony in helping to reduce the terrible sacrifice of life and limb which is annually exacted from our railroad employés.

JOHN KIRBY, }
M. N. FORNEY, } Committee.

Replies to the above questions should be sent to M. N. Forney, 45 Broadway, New York.

ANNOUNCEMENT OF FORM OF CONTOUR LINES FOR M. C. B. STANDARD AUTOMATIC CAR-COUPLERS.

An engraving is sent herewith which shows the form of contour lines for the Master Car-Builders' standard type of car-coupler, which has been adopted by the Executive Committee to consummate the recommendation of the report made to and adopted by the Association at its last annual meeting, which was that "the Association procure one of the present makes of Janney Type of Coupler, selection being made by a committee appointed for that purpose, and that all other forms of couplers that will couple to and with this coupler, under all conditions of

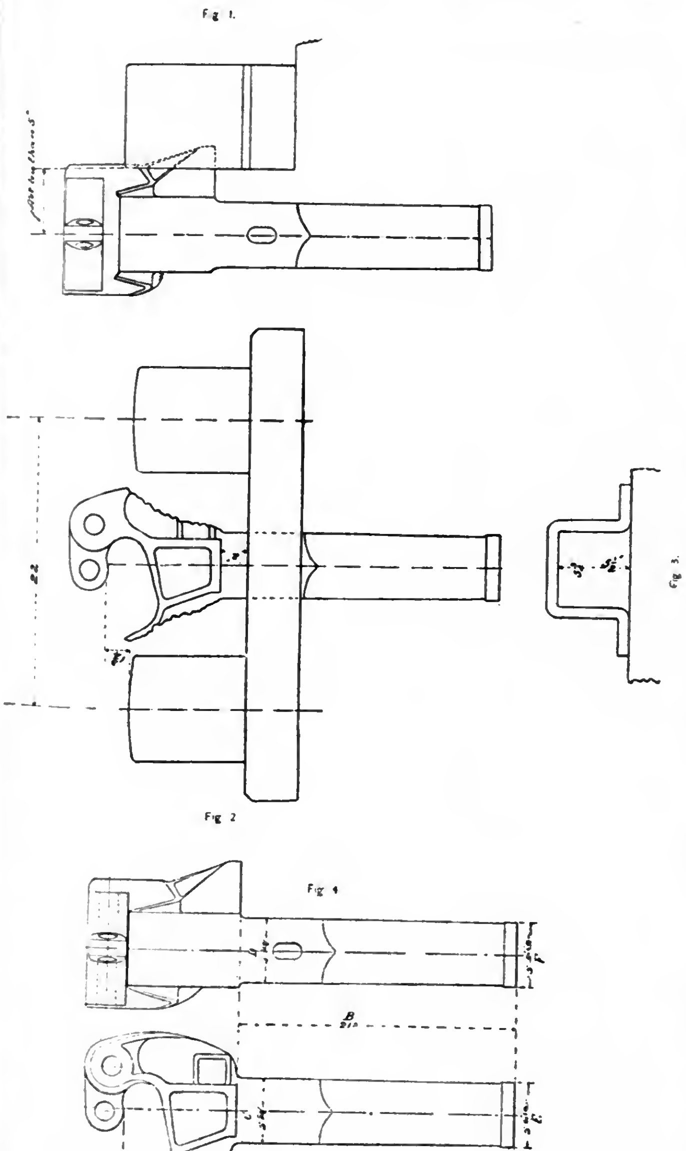
service, are to be considered as within the Janney Type and conforming to the standard of this Association."

The contour lines referred to and shown by the engraving were found to be described in Letters Patent No. 212,703, granted to Eli H. Janney, February 25, 1879, and to be covered by the 8th and 9th claims thereof.

The owners of said patent, in consideration of the adoption of the Janney type of coupler as the Master Car-Builders' standard type of freight car coupler, have agreed to waive their rights secured by said 8th and 9th claims, in favor of all railroad companies members of this Association and the Eastern and Western Railroad Associations which may decide to adopt the Master Car-Builders' type as their standard; and an agreement has been perfected whereby each railroad company may secure a license covering the right to make and use freight car-couplers containing said contour lines on making application therefor to William McConway, Vice-President of the Janney-Hien Coupler Company, Pittsburgh, Pa.

In making this concession, it will be understood that the owners of said patent do not thereby license or convey any right secured to them by the other claims of said patent or by any other patents owned or controlled by them.

In order to secure uniformity in the dimensions of the stem, dead-blocks and carrier irons and proper protection for the Master Car-Builders' type of coupler, the Executive Committee



recommend the dimensions given in the accompanying engravings (figs. 1, 2, 3, 4 and 5). The Committee are of the opinion that double dead-blocks or bumpers should invariably be used with this type of coupler. The contour lines are now the standards of the Association, and it is the purpose of the Executive Committee to submit its recommendations with reference to the dimensions of stem, etc., and the use of dead-blocks, for adoption as standards at the next convention of the Association.

By order of the Executive Committee.

M. N. Forney, Secretary.

Master Mechanics' Association.

The following circulars have been issued by Mr. Angus Sinclair, Secretary, from his office, No. 175 Dearborn Street, Chicago:

REPLIES TO CIRCULARS OF INQUIRY.

Several chairmen of committees of investigation have complained that very few replies have been received to their inquiries. As reports have to be sent to the Secretary before the meeting of the Annual Convention, it is necessary that members should reply to the circulars immediately. Members are urged to attend to this matter at once.

For the Advisory Committee,

Angus Sinclair, *Secretary.*

TWENTY-FIRST ANNUAL CONVENTION.

This Convention will meet at Alexandria Bay, N. Y., at 9 A.M., on June 19. The headquarters of the Association will be in the Thousand Island House, and rooms for members and their families may be obtained there on application to Mr. R. H. Southgate. The terms are $3 per day.

Alexandria Bay is in the Thousand Islands region, on the New York side of the St. Lawrence, near the outlet of Lake Ontario, and 12 miles from Clayton, on the Rome, Watertown & Ogdensburg Railroad. Boats connect for Alexandria Bay with all trains arriving at Clayton. Connections are made at Suspension Bridge, Niagara Falls, Rochester, Syracuse, Rome, and Utica with the Rome, Watertown & Ogdensburg Railroad. Parties from the East can make connection by the Ogdensburg & Lake Champlain Railroad, and passengers on the Grand Trunk Railway can make steamboat connection at Kingston for Clayton or at Gananoque for Alexandria Bay. Excursion tickets will be sold after June 1 from all points on the Rome, Watertown & Ogdensburg Railroad to Alexandria Bay and return.

Further particulars may be obtained from the Committee of Arrangements (H. M. Britton, Rome, Watertown & Ogdensburg Railroad, Oswego, N. Y.; R. C. Blackall, Delaware & Hudson Canal Company, Albany, N. Y.; J. Davis Barnett, Grand Trunk Railway, Port Hope, Ont.) or from the Secretary.

OBITUARY.

The pressure of other matter on our columns has, much to our regret, crowded out a number of obituary notices which should have been found in this column. The obituary list of the month is an unusually long one, including several distinguished names. We have now only space to notice them briefly. The list includes William Merritt, formerly Superintendent of the Boston & Maine Railroad, on April 15; Thomas Silvers, inventor of the marine governor and many other devices, on April 12; Alfred Hunt, President of the Bethlehem Iron Company, March 27; Clifford Rossell, head of the Pennsylvania Railroad's coal companies, April 19; Hon. John P. King, ex-United States Senator and for many years President of the Georgia Railroad Company, March 19; Samuel Smith, founder of what are now the Grant Locomotive Works, March 28; J. O. D. Lilly, Master Mechanic of the United States military railroads during the War, March 22; John M. Tufts, the oldest living graduate of West Point, March 25; Alfred Nobel, inventor of nitro-glycerine and dynamite, April 13; Thomas McKissock, engineer and railroad manager, March 22; George F. Harris, contractor and inventor of track-laying machinery, March 18; Charles E. Wright, State Geologist of Michigan, March 22; Professor James C. Booth, chemist and metallurgist, March 21; Isaac Hinckley, for many years President of the Philadelphia, Wilmington & Baltimore Railroad Company, March 28; Thomas Elliott Harrison, an eminent English engineer and pupil of Robert Stephenson, March 20; George W. Cass, graduate of West Point, engineer, and President of the Pittsburgh, Fort Wayne & Chicago Company, March 21; Charles Latimer, one of the best-known and best-loved of American engineers, March 25; General Quincy Adams Gillmore, the eminent artillerist and engineer, most prominent of all our military engineers, April 7; Squire Whipple, the venerable engineer

and father of modern American bridge building, March 15. This list is one including many whose places will not soon be filled.

PERSONALS.

D. McN. Stauffer, Associate Editor of *Engineering News*, sailed from New York, March 31, on a vacation trip of several months in Europe.

Yeija Nakajima, C.E., is Superintendent of Construction of the new water-works at Falls City, Neb., for which plans have been prepared.

Frank T. Campbell, of Newton, Ia., has been appointed a member of the Railroad Commission of Iowa, succeeding Mr. L. S. Coffin, whose term of office recently expired.

William R. Billings has resigned his office as Superintendent of the water-works at Taunton, Mass., to accept a position with the Chapman Valve Company at Indian Orchard, Mass.

E. B. Taylor, late Division Superintendent, has been appointed General Superintendent of the Pittsburgh, Cincinnati & St. Louis Railway, succeeding W. A. Baldwin, late Manager.

W. M. Clements has been appointed General Manager of all the lines of the Baltimore & Ohio Company east of the Ohio River. He has been connected with the road for a number of years.

W. W. Peabody has been appointed General Manager of all the lines of the Baltimore & Ohio Company west of the Ohio River. He was formerly in charge of the Ohio & Mississippi Railroad.

Charles Kirchhoff, Jr., for some time past Associate Editor of the *Iron Age*, has assumed full editorial charge of that journal, a position for which experience and ability very fully qualify him.

J. J. Casey has been appointed Master Car Builder of the Louisville, New Orleans & Texas Railroad. He has been for some time Superintendent of the Missouri Car & Foundry Company's works in St. Louis.

M. L. Lum has resigned the position of Chief Engineer of the Chesapeake & Ohio Railway, and the office is abolished. Mr. Lum's address is Richmond, Va., for the present.

W. G. Coolidge & Company, engineers, contractors and bridge-builders, have removed their offices to Rooms 609, 610 and 611, Phœnix Building, No. 138 Jackson Street, Chicago, Ill., where all correspondence for them should be addressed.

R. W. Bayley, recently Mechanical Engineer of the Pittsburgh, Cincinnati & St. Louis Railway, has entered the service of the Westinghouse Brake Company as General Inspector. He took an active part in the Brake Tests last year.

R. H. Soule has resigned his position as General Manager of the New York, Lake Erie & Western Railroad. Mr. Soule leaves the Erie, where he has done excellent work, for personal reasons entirely, and will take some much-needed rest before returning to work.

Charles C. Upham has resigned his position as Superintendent of the Illinois lines of the Chicago, Burlington & Quincy Railroad on account of ill-health. Mr. Upham was Chief Engineer in charge of the construction of the Chicago, Burlington & Northern Railroad.

L. S. Coffin, for three years past a member of the Railroad Commission of Iowa, has retired on account of the expiration of his term. While a railroad commissioner Mr. Coffin took an exceedingly active interest in everything relating to his office, especially in matters concerning the safety and welfare of railroad employés. He was an interested observer of the Burlington Brake Tests throughout, and the annual reports of the Iowa Commission show the result of his labors.

James C. Bayles, for 20 years past Editor of the *Iron Age*, has retired from that position on account of pressure of other business. Mr. Bayles was appointed President of the Health Department of New York City about a year ago, and in that capacity he has secured a thorough reorganization of the Department. As Editor of the *Iron Age* he has been extremely successful, and has given that journal an established position. Mr. Bayles has also been an active member of the Institute of Mining Engineers.

Dr. W. T. Barnard has resigned his position as Assistant to the President of the Baltimore & Ohio Railroad Company. He entered the service of the Company eight years ago, for the purpose of organizing a hospital department. When the Employés' Relief Organization was organized Dr. Barnard was placed at its head, the hospital being merged in the larger scheme. In that position he did some excellent work, and the success of the Association was largely due to his efforts. In 1884 he was appointed Assistant to the President, and gave up active charge of the Relief Association, although he continued to give the benefit of his advice to the Managers. Dr. Barnard was also connected with the management of the Baltimore & Ohio Telegraph, and assisted in organizing the School of Technology at the Mt. Clare shops in Baltimore. Before accepting his position with the Baltimore & Ohio, he was connected with the War Department in Washington for a number of years.

NOTES AND NEWS.

A New 150-ton Gun.—The Krupp Works are now turning out a 150-ton gun; it is similar to the 120-ton guns, but is longer and will have a much higher range. It is said that the 120-ton Krupp gun built for the Italian Government, but left at Essen when the others were sent to Italy, has been fired more than 200 times and is still in good condition.

Liquid Fuel in Russia.—The Russian Minister of Marine has decided to fit a number of new torpedo boats now under construction for the navy with furnaces for burning liquid fuel. The selection of the type of furnaces to be used will be made after the close of the competition now in progress at the Petroleum Exhibition in St. Petersburg.

At this Exhibition there are a large number of such furnaces shown, but nearly all of them are Russian or German inventions; no American or English furnaces are in the Exposition.

New Packing Ring.—A correspondent of the London *Engineer* describes a new device of this kind which has recently been brought out in Manchester. It is described as Flöring's patent, and is termed the "Metallographite." These rings are composed of very fine steel wires, and are covered with a fire-proof composition. They are inserted between the flanges and carefully flattened by the tightening of the bolt screws. They are claimed to be cheaper and more durable than india-rubber rings, and one advantage is that they can be repeatedly used after being inserted.

Priestman's Petroleum Engine.—This new engine is described in the London *Engineer* as follows: "In a tank in the bed of the engine is placed the petroleum, which is forced through a pipe into a compartment where the oil is converted into a fine spray by means of a blast of air. The spray passes into a chamber, is rendered explosive, and, coming in contact with an electric spark—obtained from a small battery in the rear—motive power is at once supplied. In construction it is comparatively simple; it works with admirable regularity, and the piston requires no oiling, the petroleum vapor supplying the necessary lubrication."

New Transatlantic Steamers.—The new twin-screw passenger steamer, *City of New York*, was launched from the ship building yard of James & George Thomson, on the Clyde, March 15. This vessel is one of the two now under construction for the Inman line, which will be the largest vessels in the world, with the exception of the *Great Eastern*, their gross tonnage being 10,500 tons. A description of these vessels was published in the Journal for March; they will be 525 ft. long on the water line, 560 ft. over all, 63½ ft. beam, and 42 ft. moulded depth. The chief peculiarities of these vessels are the system of bulkheads with which they are provided, and the use of twin screws driven by separate engines.

The Longridge Wire-Wound Gun.—The first wire gun constructed entirely on Mr. Longridge's principle by Admiral Kolokoltzoff, at the Abouchoff Steel Works, has just been successfully tested. The gun is 35 calibers long, with a powder chamber 6.84 in. diameter, and weighs 5.6 tons. The inner tube is of steel, with 85 in. of its breech-end strengthened with steel wire encased in a cast iron jacket on which the trunnions are formed, and which carries a breech mechanism of the De Bange type. The wire, weighing 1,656 lbs., is 0.252 in. wide by 0.059

in. thick, was wound on in an ordinary lathe by means of an automatic apparatus constructed by Messrs. Easton & Anderson, and attached to the saddle of the ordinary slide rest. Up to the present time 163 rounds have been fired ; 500 in all will be required to complete the test. The success of the gun so far is perfect, and completely justifies Mr. Longridge's contention that trustworthy ordnance can be constructed cheaply, and, above all, very quickly, on his system.—*London Engineer.*

The Aral-Caspian Canal.—The Russian Government has recently revised the project, first originated by Peter the Great, of diverting a part of the flow of the River Oxus, or Amu-Daria, to the Caspian Sea, and a considerable force of engineers is now employed in making surveys to test the practicability of the project. The river now flows into the Aral Sea, which has, as is well known, no outlet. The diversion of part of its flow into the Caspian Sea would have the effect probably of reducing the area of the Aral Sea and the great marshes which surround it considerably, but it is not considered that such a result would be undesirable. The intention of Peter the Great was to make a navigable canal by which vessels on the Caspian could penetrate into Central Asia. The building of the Russian Military Railroad has done away with the necessity for this, and the present object of the Government is not so much to make a navigable canal, as to secure a supply of water which can be used to irrigate the great plain between the Caspian and Aral. Recent examination has lead the Russian engineers to believe that a very large part of this district can be cultivated, provided a supply of water can be secured.

Draining the Zuyder Zee.—The preliminary work for the drainage of the Zuyder Zee in Holland is progressing well and excites much interest in that country. If the enterprise is successful it will remove altogether this troublesome and turbulent inlet from the North Sea, and will add a new province to the country.

For the purpose of pushing the project energetically a company was last year formed, which is known as the Zuyder Zee Union. A distinguished Dutch engineer has made a careful study of the proposed work and has submitted his plans. According to these the province of North Holland will be connected with Friesland and Groningen by two great dykes. As soon as these are completed the work of draining the land will be begun. The entire area of the Zuyder Zee will be drained, except a small portion, which will be left as a permanent lake ; a large canal will run from this lake to Amsterdam. This lake will receive the waters of the River Yssel on the one side, and on the other it will have a connection with the North Sea through several locks. The Union has recently taken a subscription of 90,000 gulden to continue the preparatory works.

Boiler Explosions in France.—The Ministry of Public Works reports that there were in France last year 30 boiler explosions, by which 33 persons were killed and 24 injured. The classes of boilers which exploded were :

Boilers without interior fire-box :

Horizontal, not tubular	10
Horizontal, tubular	1
Vertical	2

Boilers with interior fire-box :

Horizontal, tubular	8
Vertical	1
Receivers and other steam apparatus	8
Total	30

The causes assigned were : Defective construction or material, 9 ; fatigue of metal or grooving of plates, 9 ; repairs neglected or badly made, 3 ; low water, 6 ; excessive pressure, 3 ; other cases of neglect, 3 ; unknown, 3.

It will be observed that the number of causes given is greater than that of explosions ; this arises from the fact that in several cases more than one cause is assigned for an explosion.

Traffic of the Suez Canal.—The number of ships which passed through the Suez Canal last year was 3,137, their gross tonnage being 8,430,043 tons. The largest movement of shipping through the canal in any one month occurred in May, when 303 ships of an aggregate burden of 797,547 tons paid transit dues. Of the 3,137 ships which went through the canal last year 2,330 were English, leaving a balance of only 807 carrying the flags of other nations. In this total of 807 ships, France figured for 183 ; Germany for 159 ; Italy for 138 ; Holland for 123 ; Austria (and Hungary) for 82 ; Norway for 28 ; Spain for 26 ; and Russia for 22. Only three American vessels used the canal in 1887. The number of persons passing through the canal as passengers last year was 173,786, of whom 91,996 were soldiers, 53,415 civil passengers, and 19,610 Mohammedan pilgrims. The total of 3,137 ships passing through the canal last year compared with a passage of 3,100 in 1886 ; 3,624 in 1885 ; 3,284 in 1884 ; and 3,307 in 1883. The average time occupied by each ship in the canal last year was 34 hours, as compared with 36 hours in 1886 ; 43 hours in 1885 ; 42 hours in 1884 ; and 48½ hours in 1883. The considerable reduction observable in the average in 1887 and 1886 is due to sundry extensions and improvements carried out since 1885, which have considerably facilitated the passage of shipping.

The Mekarski Air Engine.—After various delays several tram-cars driven by compressed air on the Mékarski system have recently been placed on a tramway line in the north of London, where they are regularly taking their turn in working the traffic with the ordinary horse-drawn cars. The Mékarski system consists of a station where the air is compressed and stored for delivery into reservoirs placed under the cars. The air in its passage from the reservoirs to the driving engines, which are also under the cars, passes through hot water and steam, which are charged into a receiver on the car at the compressing station. The heat further expands the air, and also prevents the formation of snow in the cylinders due to the expansion of the compressed air. The tramway upon which the cars are running is that section of the London Street Tramways Company's lines between Holloway Road and the King's Cross Station of the Metropolitan Railway. It is about two miles in length, and has several heavy gradients and sharp curves. The Mékarski cars, which resemble the ordinary horse-drawn cars, take their turn regularly with the other cars on the line, keeping time and observing all the other conditions of traffic. The introduction of the air-driven cars by the Tramways Company on its line has been decided on in consequence of the economy of the system over horse traction, and this notwithstanding that both horses and forage are at comparatively low prices.

A Cable Railroad in Venezuela.—The Government of Venezuela has recently granted a concession giving the La Guayra & Caracas Cable Company, represented by T. W. Tyrer, the exclusive right to build and operate a cable railroad between the port of La Guayra and the city of Caracas. The Company is to begin the work of construction within nine months from December 1, 1887, and to complete the road in three years. It is to have an exclusive right for 99 years, the Government agreeing that no company or person shall be allowed to operate a parallel or competing line. The Company is also to have the right to build stations, warehouses, and wharves at La Guayra and to build necessary stations and warehouses at Caracas. It is to have free right of way and a grant of land for terminal buildings at both ends of the line. The maximum fares and rates of freight to be charged are prescribed, and the Company is required to carry Government freight, soldiers, and other passengers on public service at one half the maximum rate.

The construction will involve some difficult engineering. The city of Caracas, which is the capital of Venezuela, is only a few miles distant from La Guayra in a direct line, but is several thousand feet above it, and the journey between the two places involves the crossing of the lofty mountain range. The cable road was considered the only practicable method of overcoming the extremely heavy grades which would be necessary in any line between the two places which did not make a very wide circuit. The building of the line will also involve the construction of several tunnels of considerable length.

Naval Notes.—The Secretary of the Navy has approved the modified plans for the machinery of the *San Francisco* to be constructed by the Union Iron Works. The plans call for triple-expansion twin-screw engines of 36 in. stroke ; diameter of cylinders, 42, 60 and 94 in., respectively ; horse power, 11,000. All engine frames and pillow-blocks of forged steel ; all crank shaft pillow-blocks, links, and valve gear interchangeable ; the crank-shafts made in sections all alike and interchangeable so that there is no chance of a complete break down ; valves of the piston type for the high pressure and intermediate cylinders ; air pump double, and worked independently of the main engines ; condensers cylindrical and built of brass and composition with a total cooling surface of 14,500 square feet ; four double-ended cylindrical boilers with a total heating surface of 19,500 square feet ; also an auxiliary boiler. The draught to be forced by eight blowers blowing into closed ash-pans.

The Richmond Locomotive Works (formerly the Tanner & Delaney Engine Company) will, it is said, receive the contract to build the engines for the *Texas*, the battleship which is to be built at the Norfolk Navy Yard.

The contract for the building of the new torpedo boat by the Herreshoff Company has been concluded. The construction of this boat will be under the supervision of the Bureau of

Ordnance. The force of draftsmen in the Bureau of Steam Engineering is busily engaged on the plans for the machinery of the *Monadnock*, the unfinished monitor at the Mare Island Navy Yard, California.

The Standard Steel Company at Chester, Pa., has cast a 6-in. steel gun, weighing 12½ tons. It is of Siemens-Martin steel, and the casting was, apparently, a success. It will be bored and turned up, and then subjected to the same tests as the Pittsburgh cast-steel gun.

Photographing the Pacific Coast.—Professor Davidson, of the Coast Survey, has long since planned a scheme for photographing the whole line of the Pacific seaboard from selected stations, say at distances of 10 and 20 miles broad off the shore. The farther ones would give the landfall or crest line of the coast mountains as it would appear to the navigator approaching the coast directly from seaward. The stations along the seaboard would be not over 10 miles apart and probably less. The inner line of stations would give the details to the steamships and sailing vessels coasting northward and southward. In addition to these two series there would be a set of three views of every headland as seen when approaching it from the southward, when abreast of it, and when approaching it from the northward. The islands would be sketched or photographed from four or more directions according to circumstances.

Views for channel ranges are very important in approaching and entering bays and ports, and are particularly useful for approaching dangerous anchorages, such as the many landings, chutes, and harbors visited by our smaller lumber vessels and produce schooners.

There is evidently an immense amount of this kind of work to do, and Superintendent Thorn has just transmitted to Professor Davidson a copy of the authority given by the Secretary of the Treasury to Captain Shepard, commanding the revenue cutter *Rush*, to receive him on board his vessel, in order that he may take views along that part of the coast where the vessel will be cruising.—*San Francisco Call.*

Blast Furnaces of the United States.—The *American Manufacturer*, in its usual monthly tables, gives the condition of the blast furnaces of the United States on April 1.

"The totals are as follows:

	In Blast.		Out of Blast.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	60	12,393	114	12,996
Anthracite	95	27,971	105	27,373
Bituminous	130	75,983	84	44,928
Total	285	116,347	303	85,297

"The appended table shows the number of furnaces in blast on April 1, 1888, and on April 1, 1887, with their weekly capacity:

	April 1, 1887.		April 1, 1888.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	59	11,337	60	12,393
Anthracite	143	39,477	95	27,971
Bituminous	151	86,709	130	75,983
Total	353	137,523	285	116,347

"This table shows the following changes during the year: Charcoal—increase in number of furnaces blowing, 1; increase in weekly capacity, 1,056 tons; anthracite—decrease in number of furnaces blowing, 48; decrease in weekly capacity, 11,506 tons; bituminous—decrease in number of furnaces blowing, 21; decrease in weekly capacity, 10,726 tons. Total decrease of number in blast, 68; total decrease in weekly capacity, 21,176 tons."

Origin of Artesian Wells.—The sedimentary rocks, in their great thickness, inclose a succession of water-sheets or water-levels occupying distinct stages, and extending, with uniform characters, under whole countries, like the strata to which they are subordinated. It is proper to remark here that by the term water-sheet is not meant a real bed of water, lodged in a cavity, between solid masses that serve as walls to it, but water filling the minute interstices or the cracks of a rock. Continuous and regular in sand, these sheets are usually discontinuous and irregular in limestones and sandstones, in which the water only occupies more or less spacious fissures. When natural issues are wanting, human industry is able, by boring, to make openings down to the subterranean waters, which it causes to jet up to the surface, and sometimes to a considerable height above. The thought of undertaking such works is a very ancient one. The Egyptians had recourse to them 40 centuries ago; and they were executed in France, in 1126, at Artois, whence the name of artesian wells has been given to them.

The water-levels of the cretaceous strata, from which the French artesian waters issue, are not always of advantage; but in the north of France and in Belgium they constitute the most formidable obstacle which miners have to encounter in reaching the coal-beds.

A striking confirmation of the theory of the source of supply of the artesian waters has been observed at Tours, where the water, spouting with great velocity from a well 110 meters in depth, brings up, together with fine sand, fresh-water shells and seeds, in such a state of preservation as to show that they could not have been more than three or four months on their voyage. Some of the wells of the Wady Rir have also ejected fresh-water mollusks, fish, and crabs, still living, which must, therefore, have made a still more rapid transit.—*Professor G. A. Daubree, in Popular Science Monthly.*

The German Universal Exposition for Prevention of Accidents.—Minister Pendleton, at Berlin, transmits to the State Department a letter from the President of this Exposition for the purpose of making known in the United States the objects to be attained. The Exposition is to be held in Berlin from April to July, 1889, and is to contain apparatus and appliances meant to protect workmen against the dangers which threaten them in industrial occupations, from the knowledge and introduction of which a reduction in the number of industrial accidents may be expected.

The humanitarian views which prompt this Exposition have won the full sympathy and support, not only of the principal representatives of industry and agriculture in Germany, but also of the German Imperial and Prussian state officials.

As may be seen from the full programme, the Exposition aims not only to promote a knowledge of the apparatus and appliances calculated to prevent accidents, but also to stimulate an interest in their further development, and to furnish the inventors of similar protective contrivances an opportunity to demonstrate their practical utility. The Exposition will, therefore, have much of the character of an industrial exposition, differing only from the purely industrial expositions in that such articles only will be admitted whose aim or make has a demonstrable relation to the prevention of accidents. Such articles and appliances may also be admitted which tend to the workmen's protection and general welfare, and are therefore to lead directly or indirectly to a diminution of industrial accidents.

As the workmen and handicraftsmen of all lands have an equal concern in the decrease of accidents in industrial occupations, there can be no doubt that this Exposition will also be of interest for other countries, especially as, according to the "Conditions for Exhibitors" found in the programme, foreigners are allowed to enter their exhibits.

Internal Stresses in Guns.—From the failures which frequently occur with guns of large caliber, it would appear that the initial stresses in the interior of the metal of the various rings, which have hitherto been treated in practice as negligible quantities, have an importance as yet not properly allowed for by their designers. The reason of such neglect is by no means obvious, as in the case of ordinary cast-iron guns, their importance has long been known, and acted on in a practical way by Rodman and others, but in modern steel guns, where both theory and experiment concur in the conclusion that their effects are intensified, they have, until lately, been treated as non-existent. This increase, in the case of steel, is due to the higher elastic limit of this metal as compared with cast iron, for the internal stresses cannot exceed that corresponding to the elastic limit, or the metal will take a permanent set and relieve itself of the excess, and consequently the value of the stresses in question can attain a much higher value with the more modern material. The only person who seems to have fully understood the great importance of these internal stresses is General N. V. Kalakouski, of the Russian Artillery, who has carried out a most painstaking and laborious series of experiments with a view to determining the actual values attained by these stresses in different cases, and of these experiments a fairly complete account is given in a recent issue of the *Revue d'Artillerie*. The plan adopted was to cut disks of metal from steel cylinders, and to engrave on the face of each a series of concentric circles, dividing the disk up into a series of annular rings, the diameters of which were then carefully measured. The rings were then turned off successively in a lathe, fresh measurements of the diameters being made between each operation. It was then found that the values of the diameters had in general changed, thus proving the existence of internal stresses, the numerical values of which could be computed from the diametrical alterations, and frequently amounted to many tons per square inch.

THE RAILROAD AND

ENGINEERING

JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

PUBLISHED MONTHLY AT No. 45 BROADWAY, NEW YORK.

M. N. FORNEY, ... Editor and Proprietor.
FREDERICK HOBART. . . . . Associate Editor.

Entered at the Post Office at New York City as Second-Class Mail Matter.

SUBSCRIPTION RATES.

Subscription, per annum, Postage prepaid..............$3 00
Subscription, per annum, Foreign Countries............ 3 50
Single copies.. 25

Remittances should be made by Express Money-Order, Draft, P. O. Money-Order or Registered Letter.

MR. J. HOWARD BARNARD, 7 Montgomery Avenue, San Francisco, Cal., is the authorized Western Agent for the JOURNAL.

MR. FREDERIC ALGAR, Nos. 11 and 12 Clements Lane, Lombard Street, London, E. C., England, is the authorized European Agent for the JOURNAL.

NEW YORK, JUNE, 1888.

THE difficulty of controlling a river like the Mississippi is once more shown by the spring floods of the present year. The river is higher now, in its upper course, than it has been for many years, and it has practically destroyed all the levees between the mouth of the Des Moines and the Missouri, including some which have been built with unusual care and at great expense, and which were considered safe against any possible flood. The results have been disastrous, a large extent of very fertile bottom land being overflowed and its value destroyed for the present. The flood has also caused much embarrassment to the railroads, the destruction to embankments and bridges in the overflowed district being considerable and the interruption to traffic serious. The high water has not yet reached the lower river, although some of its southern tributaries, including the Arkansas and the White rivers, are reported as being very full.

A SPECIAL report was recently submitted by the Massachusetts Railroad Commission to the Legislature on the question of heating and lighting passenger cars. The Commission employed Professor Lanza, of the Massachusetts Institute of Technology, to make a careful examination of the various systems of steam-heating and of the difficulties encountered in their operation. An elaborate report submitted by him confirms the Board in the opinion that the system of heating by steam from the locomotive is not only practicable and safe, but is also desirable as a measure of economy, and that it should be adopted as a standard for the State. After considering all the circumstances of the case, and the difficulties to be encountered in making the necessary changes, the Board has decided that there would hardly be time during the present season to change all the cars employed on railroads of the State, and that it would be unreasonable to insist upon the general adoption of any continuous heating system next winter. They have therefore decided, in pursuance of the authority given them by law, to postpone the time when the use of separate heaters will be absolutely forbidden until October, 1889, in the mean time urging the companies to use all reasonable diligence to prepare their cars for steam-heating.

More progress has probably been made toward the adoption of continuous heating systems in Massachusetts than in any other State. The time allowed by the Commissioners is ample, and the railroad companies certainly cannot complain that they are compelled to make the change without sufficient notice.

MENTION has been heretofore made of the rapid progress of railroad consolidation in New England by the absorption of the smaller lines by lease or consolidation. The Boston & Maine is the most conspicuous instance of this; but a later one is the case of the Old Colony Company, which has just completed and rounded out its system by the lease of the Boston & Providence road. There have been some reports that this Company, having thus secured one end of the Shore Line between New York and Boston, would endeavor to strengthen its position by adding to its system the New York, Providence & Boston road, which is an important link in that line, extending from Providence to New London. The advantage of such a lease would have been twofold: The Old Colony would have protected itself against a possible parallel line between Providence and Boston, and at the same time would have secured control of the Stonington Steamboat Line, which is the most important rival of its own steamer line between New York and Boston. Rumors of such a consolidation were prevalent, but they have been contradicted, and the New York, Providence & Boston Company has at the same time asserted its independence and shown its intention to strengthen itself against competition by leasing the Providence & Worcester Railroad. By that lease it secures a line which has important connections, and which controls the business of a large and very active manufacturing district.

This is not the end of consolidation, however, and there are rumors which have, apparently, some basis, that negotiations are pending for the lease of the New York, Providence & Boston to the New York, New Haven & Hartford Company. This is not improbable, although the relations of the two companies are such that a lease would really make little practical difference beyond putting both lines under a single managing head.

THE directors of the Baltimore & Ohio Railroad Company have appointed special committees to examine carefully both the financial and physical condition of its property, and to prepare a plan for a complete reorganization of its management. This is the first result of the change in the control of the company which was brought about last year, and, so far as it goes, it is an excellent one. While the conservative methods of the Baltimore & Ohio were wise in some respects, they have been carried to an extreme, and the road has been, in many points, entirely behind its competitors. It has been controlled, so far as its operating and constructing departments are concerned, by men who looked backward and not forward, with results that have in some cases been disastrous. Then, too, there has always been too much of the one-man power in the management, and subordinate officers have never had

proper authority or responsibility in their o[illegible]epartments, the result being to make them mere r[illegible]ies to record orders from headquarters, and to drive away from the road men who felt themselves capable of doing better. To enumerate all the weak points of the system would take too long, but it is to be hoped that the present opportunity will not be allowed to pass, and that reorganization will be so thorough and so complete as to permit improvement and advance hereafter in the right direction.

One of the first steps taken has been a curtailment of the powers and duties of the office of Purchasing Agent, which have heretofore been curiously and abnormally large on this road.

FRANCE has generally been considered somewhat backward in sanitary science when compared with England or the United States, and the charge is to some extent true. French engineers appreciate this, however, and are doing their best to secure improvement. The paper of M. Mayer on "Sewers," the second number of which will be found elsewhere, is a very interesting one. M. Mayer has studied his subject carefully, and has the French disposition to classify and generalize which is often admirable in an essay of this kind. The paper is written with special reference to the needs of smaller cities, and contains much that will be applicable here as well as in France.

ONE scheme for a new rapid transit line in New York has received a decided set-back, the Supreme Court having decided against the claim of the so-called Metropolitan Transit Company to a right to build an elevated railroad through Broadway. The company's charter provided originally for an entirely different line, but the attempt to build the Broadway route was made under a clause of that charter authorizing certain branches. The Court now holds that, as the main line proposed was never built, the authority to build a branch could not be established, and that in any case a line extending through Broadway from the Battery to Madison Square could not be considered such a branch as the charter referred to. The defeat of this plan will not cause any regret among the people of the city generally.

THE vexed question of the street crossings of the Philadelphia & Reading Railroad in Philadelphia, is probably to be solved by the construction of an elevated railroad from the station at Ninth and Green streets to a point on the outskirts of the city. The new tracks are to be built by an auxiliary company, and an ordinance authorizing their construction is now pending in the City Council. The character of the proposed structure is to be very similar to that of the elevated line by which the Pennsylvania Railroad reaches the Broad Street Station in the same city. Some slight changes in street grades will be required, and also the vacation of some streets, to permit the enlargement of the station. The new line will have four passenger tracks, two of them to be used for the main line traffic and the other two probably for city traffic, local stations to be established at various points. Some modification may be required in the plans as at first submitted in order to meet the views of the City Council and to avoid interference with local interests, but there seems to be little doubt that the elevated line will be built, and that it will be in the end a benefit both to the city and the railroad company.

ANOTHER grade crossing question, which has caused some friction in another part of the country, is also about to meet with a settlement by the construction of a new line for the Boston & Albany Railroad through the city of Springfield, Mass. The road, which now crosses one of the most important streets in that city at grade, is to be raised, and carried over Main Street by a stone arch bridge, and will enter the station at a higher level than at present. This improvement is undertaken in connection with the building of a new station; the change has been agitated for some time, but, as in all such cases, so many interests were to be considered that it was not easy to reach a final agreement.

THE latest addition to the Navy is the little steamer *Stiletto*, which has been purchased by the Navy Department from the builders, the Herreshoff Brothers, for $25,000. The *Stiletto* was built as a steam-yacht and to establish the practicability of certain theories in relation to model and engines. She is one of the fastest vessels of her size ever built, if not the fastest, having attained the extraordinary speed of 23 knots an hour, and having proved her ability to keep up that speed for a considerable length of time. She is only 90 ft. long and 11 ft. beam, with a mean draft of 3 ft. and a displacement of 356 tons. In the Navy the *Stiletto* will be classed as a second-rate torpedo boat, and will be armed and equipped accordingly.

THE cast steel gun made for the Navy by the Pittsburgh Steel Casting Company is now ready to be rifled. The rifling in itself will be somewhat of a test of the condition of the gun, and it will be speedily followed by the firing and endurance tests at the Naval proving grounds. The steel gun cast at Chester will also soon be ready for trial. The tests of these guns, which will come in competition with the built-up guns, which have found favor with Naval officers both here and abroad, will be watched with a great deal of interest.

THE Naval War College, it is stated, is to be discontinued hereafter, on account of the absence of any provision for its expenses. This is to be regretted, for it was without doubt of much benefit to the officers who were able to attend it, and to the service generally. If its methods were open to criticism it would have been much better to amend them than to discontinue the college altogether. Naval science is progressive, and is just now in such a transition state that the young officer who graduates from Annapolis has really only begun the study of his profession.

STEEL turret-forts, which have met with considerable favor with French engineers, and which have been much discussed in military circles in Europe, seem to have failed conspicuously in some recent tests made with the forts at St. Chamond, in France. The forts, in these cases, were built of concrete, the guns being contained in steel turrets, with suitable machinery for lowering them behind the concrete screen when they were not in action, and for raising them when it was necessary to use the gun against an enemy. The concrete resisted projectiles very well, but the steel turret itself suffered very badly, and it was found that the shots not only penetrated and damaged the turrets, but that the steel splinters detached by their impact became

in themselves projectiles capable of inflicting terrible injuries to the men employed in working the guns of the turret. It is true that these tests were made with shots fired at a shorter range than would probably be the case in actual warfare, but they were sufficient, in the judgment of engineers who witnessed them, to show that steel forts were not by any means to be relied upon. The turrets could be sheltered by lowering them behind the concrete shield, but in that position the guns could not be fired, and a fort which merely opposes resistance to the attack of an enemy, but does not possess any power to retaliate, would be of no service, and could be safely ignored by the opposing force.

"NOTES ON STEAM HAMMERS," the first chapters of which will be found on another page, are written, as stated last month, by an eminent French engineer who has had many years' experience in the management of extensive iron works. The work received this year the prize offered by the Society of Alumni of the École Nationale des Arts et Métiers. Our translation is made by special arrangement with M. Chomienne, and from his manuscript, containing a number of additions not found in the French edition as printed.

No standard work on this subject is in existence, and it is hoped that these articles will prove an acceptable addition to engineering literature.

THE War Department is naturally opposed to the Cullom Bill providing for the organization of a new department or bureau for the management of the public works of the United States. In response to a request from the Senate Committee having the matter in charge, Secretary Endicott has submitted reasons why the management of the river and harbor works should be left with the Engineering Corps, which has always had charge of it.

The Council of Engineering Societies, which has been agitating this matter, reports that there is very little doubt that the Cullom Bill will pass the Senate, and will probably meet with very little opposition in the House. In the present condition of the business in the latter body, however, it is to be feared that the bill, if it comes up at all this session, will not meet with the careful consideration which so important a measure should have.

In this connection it may be noted that the bill originated, and has had its main support, among Western engineers. The Eastern members of the profession, while they have not generally opposed it, at least have not been active advocates of the bill, few of them, in fact, having expressed any definite opinion. The majority have apparently regarded it as a matter of small importance, or believed that it was not likely to be adopted.

The most serious objection to the proposed plan seems to be the difficulty of organizing the Bureau at the outset. A large number of new officers are provided for, but there is very great risk that many of the subordinate positions may be filled by incompetent persons, whom it might not be easy to weed out later. Many other objections might be suggested, which there is not room to consider at present.

AN attempt to cross the Atlantic in a balloon is to be made by M. Jovis, a French aeronaut, who claims to have invented machinery for directing the movements of his air ship which will render his attempt a fairly safe one. M. Jovis does not go so far as some previous inventors have done, and assert that he can make himself independent of the wind, but he does claim that he will be able to steer his balloon and utilize the force of the wind very much as can be done in sailing a ship. The attempt will be watched with curiosity, but without much hope of any practical result.

THE Russian Trans-Caspian line is now complete to the ancient city of Samarcand, and was to be formally opened to that point on May 27. The work is still being pushed forward on the extension of the line, and the engineers, it is said, are now engaged in ascertaining whether a branch can be extended northward into Siberia to meet the Pacific line, which is under construction through that country, without encountering too great difficulties.

It is said that the line is receiving an unexpected amount of commercial traffic. It has been built—as our readers will doubtless remember—entirely as a military line for the purpose of supporting the Russian power in Central Asia, but it follows so nearly the routes upon which caravans have traveled for many centuries, that it has naturally attracted to it a trade which will continue to grow, and which will be very considerably increased when the main line reaches its expected terminus at or near the western border of China.

The Siberian Branch, should it be built, will be necessarily more of a military than a commercial line, as it will be a much less direct line to the Amoor settlements and the Pacific than the direct Siberian line, which will be an extension of the Ural Railroad. It might, however, serve to carry petroleum from the Caspian oil region to Siberia, although this is not likely ever to be a very great traffic.

The effect of the railroad on the turbulent nomads, who form the greater part of the population of the country, has been very similar to that which the building of roads across the Plains had upon our own Indians, and from a military point of view it has already proved of inestimable value to the Russians. The moral effect upon the Turkomans—a people especially open to such impressions—of the establishment of an important railroad and military station in their ancient sacred city will be very great.

THE RAILROAD AND ENGINEERING JOURNAL, and with it the "Catechism of the Locomotive," has an established circulation in Europe, Asia, and Africa, as well as in America. To the four continents must now be added the isles of the sea, as is shown by the following extract from a letter received from the Manager of the Hawaiian Railroad with a request for back numbers: "Many of the half-natives in our employ have furnished themselves with your 'Catechism.' This is very flattering to you, for they very seldom, if ever, read—not even stories. It is, perhaps, unnecessary to say that they have been of the greatest help to us."

THE New England Water-Works Association, which is a very lively and active technical society, will hold its annual meeting at Providence, June 13, and the programme shows that the questions which will be brought up for discussion have a very direct and practical bearing upon the interests managed by the members of the Association. The meeting is sure to be an interesting one.

Two important Mexican contracts are now reported let to English parties. One is for the completion of the railroad across the Isthmus of Tehuantepec from Coatzacoalcos on the Gulf to Salina Cruz on the Pacific, on which some work has already been done. The new contractors are to put the partially built section of this line in good order, and finish the line in four years, receiving their pay in bonds, with a large bonus if the work is finished in less time. The railroad is to be State property when completed.

The other contract is for the construction of the Tequixquiac Tunnel, which is to complete the great system of drainage designed for the high plateau upon which the City of Mexico stands. This tunnel is to be 9,250 ft. long, and is to be the outlet for the city sewers, the proper clearing of which has been rendered impossible by the peculiar topography of the city and its surrounding country. About 1,000 ft. of the tunnel have been excavated under a previous contract. The contractors, a London syndicate, are to be paid for the work in city bonds.

The New York aldermen have refused to grant permission for the use of electric cars on the Fourth Avenue line. The opponents of the measure professed to be moved by a tender regard for the personal safety of their constituents, and in debate showed a most profound ignorance as to what the precise danger was, and, indeed, as to everything connected with the system. A New York alderman, however, can usually be trusted to protect the city from everybody and everything except—himself.

THE NEW INTER-OCEANIC CANALS.

Two of the greatest and most important engineering works now in hand, which are attracting attention not only in this country but abroad, have the same object in view—the providing a navigable channel between the waters of the Atlantic and the Pacific oceans by which vessels may be able to avoid the voyage around the Continent of South America, which is now necessary.

The first of these, the Panama Canal, which crosses, or is to cross, the Isthmus connecting the two Continents at its narrowest part, has been in progress several years, and an enormous amount of money has already been spent upon it. For several reasons, however, chief among which have been the absence at the outset of a proper knowledge of the work to be done and the difficulties to be encountered, and the lack of a thoroughly competent engineering head, this project is just now in serious difficulties. The money which, it was expected, would be sufficient to build it has been raised and spent, and it is still several years from completion, even according to the estimate of its most sanguine advocates. The original plan for a sea-level channel or open cut has been practically abandoned, and its place taken by a canal with locks, which will reduce enormously the amount of excavation required. Even with this concession the time set for its completion will necessarily be postponed for several years beyond that originally appointed, and it is yet uncertain as to whether the company will be able to carry it through; for if the engineers finally succeed in overcoming physical obstacles, there still remains to be faced the difficulty of raising the money required; although there is a bare chance that the pride and ignorance of French investors may make this possible.

The Panama Canal has never been regarded with special favor in the United States, partly because it has been so exclusively a French project and partly because of a lack of confidence in its managers; and the attempt to raise money here for it was an absolute failure. Americans generally look upon the difficulties, or even the prospective failure, of the project with indifference.

The Nicaragua Canal, although it has not yet advanced beyond the stage of a survey and location, possesses more elements of strength. The difficulties to be overcome from an engineering point of view are very much less, and the actual amount of excavation is comparatively smaller; and while the work will be on a sufficiently grand scale, it is still a less costly and much more practical plan than the crossing at Panama. It has been from the beginning an American project, and has met with much favor on this side of the water. At present there seems to be no obstacle in the way of its construction which cannot be overcome, and it is not impossible that vessels may be passing through it from one ocean to the other quite as soon, if not sooner, than through the Panama Canal.

Whatever may be the result as to construction, it seems to us that the projectors of both these enterprises have committed the serious error of largely overestimating the probable traffic which will be attracted to one or both canals, and consequently the financial results which might be expected from them. The calculations which have been made have been based on statistics which are necessarily imperfect and some of them unreliable, and the statisticians (of the Panama Company at least) have evidently been guided in their estimates to a great extent by the figures of traffic for the earlier years of the Suez Canal. Now the business which awaited the opening of that work was much greater in amount than that which waits for the opening of the Panama or the Nicaragua canals, and, moreover, the conditions of ocean traffic have materially changed during the years which have elapsed since vessels first passed between the Mediterranean and the Red Sea.

At that time the advantages gained by shortening the voyage between western Europe and India and China were very much greater from a money point of view than now, and the result of this change has already been felt in a steady and definite falling off in the revenues of the Suez Canal, which has been going on for several years, while at the same time the business has been steadily increasing. The substitution of the triple-expansion marine engine and the use of steam at high pressure for the low-pressure engine, has not only effected a great economy in the consumption of coal, but has also largely reduced the space occupied in a ship by the engines and boilers, leaving more stowage room for cargo. A vessel of the same tonnage and about the same cost can now carry more paying freight and has a wider traffic range—that is, the distance she can steam with such an amount of coal as she can afford to carry is much greater than was the case 20 years ago.

In this way the relative effect of the shortening of a voyage has been diminished, and this is an important element to be taken into account in estimating the prospect of the inter-oceanic canals.

It must be considered that, on the one hand, it will be necessary to charge sufficient rates of toll upon vessels passing through the canal to provide for its maintenance

and other expenses and for moderate interest on its cost. On the other hand, it is necessary that these tolls should not be so high as to keep business away from the canal.

The projectors claim that on voyages between European ports and the western coasts of both North and South America either of the projected canals will save nearly one-half of the length of a steamer trip and considerably more than one-half of its risk. It is evident that the advantages thus gained will be very great. If a steamer carrying wheat from San Francisco, loaded with copper from Valparaiso or nitrates from Peru to Liverpool, can make four trips in a year instead of two, it is manifest that her earning capacity will be doubled with a comparatively small increase of working expenses, for the important element of seamen's wages in the running cost, and the other important items of interest and depreciation would not be increased at all ; and from this point of view her owners could afford to pay a considerable amount to the canal and still have a profit left.

The competition for ocean freights, however, is extremely keen and rates are very low, so that ship-owners are compelled to figure very closely ; and it would be easy to place the canal tolls at such a point that it would be more profitable for a ship to take the longer and more dangerous voyage. In such a case the effort to secure a proper return upon the cost of the canal would defeat itself by driving away the business which should support it.

If, as we have said, it is probable that an overestimate of the traffic has been made, and that it would be barely sufficient to support and pay interest on a single canal, it is much more likely that if two are built the financial results will be disastrous. In that case there will be a competition for business, and not only will the traffic be divided, but—as some of our railroads have found in similar cases—the rates must be lowered. The business will not only be decreased, but its value will be diminished, and that which might possibly make a return on one of these works would be plainly insufficient to do so on both.

Another source of revenue on which large expectations are based is an expected increase in water traffic between the Atlantic and Pacific coasts of the United States. But this is not to be relied on, for with the railroad competition rates on this business must always be very low, and it is only the heaviest and cheapest class of freight which will go by sea. With this time is not usually an element of any importance, and a very small difference in expense would be enough to send it by a different route than the canal.

With full account taken of all these considerations, it is, however, probable that a single canal will pay after a time, if not at first. Both as an engineering work and a financial undertaking the Nicaragua Canal seems to be the best project, and its success is much to be desired.

NEW PUBLICATIONS.

STATISTICS OF THE AMERICAN AND FOREIGN IRON TRADES FOR 1887 : ANNUAL STATISTICAL REPORT OF THE AMERICAN IRON & STEEL ASSOCIATION : JAMES M. SWANK, GENERAL MANAGER. Philadelphia ; published by the American Iron & Steel Association.

This report for 1887 contains the usual complete and valuable compendium of statistics which make this publication really indispensable to all who are interested in the iron and steel trade. It covers the most active year in the history of the American iron trade, the output of iron and steel in all their leading forms having been greater than in any previous year. All branches of the trade reported increases, with the single exception of the makers of cut nails, and in this case the reduction is explained and made up by an extraordinary increase in the production of wire nails, which are taking the place of cut nails in the market to a great extent.

While 1887 was a year of unprecedented activity, it was not one of uniform prosperity. The last quarter of the year was marked by a general shrinkage in prices, due to various causes, but largely to a general belief that the general activity, and especially the demand for material for new railroads, could not be kept up much longer. These anticipations have been partly justified by the course of business during the first quarter of 1888.

Mr. Swank, whose position and experience give him exceptional opportunities for forming an opinion, is hopeful of improvement, for he says : "It would not, however, be correct to assume that the first quarter of the new year closes with general depression in our iron and steel industries. The shrinkage in demand is most marked in steel rails, and is next most noticeable in pig iron, bar iron, and wrought-iron pipe. But the consumption of pig iron for miscellaneous purposes is still large, and the steel-rail manufacturers have already entered orders for a large quantity of steel rails, which will be needed in 1888 for renewals and extensions, as well as for some new railroads which must be built. The bridge works of the country, the foundries, the machine shops, the car-builders, and car-wheel makers, the locomotive builders, and many other consumers of iron and steel are still very busy."

THE DESIGN AND CONSTRUCTION OF MASONRY DAMS, GIVING THE METHOD EMPLOYED IN DETERMINING THE PROFILE OF THE QUAKER BRIDGE DAM : BY EDWARD WEGMANN, JR., C.E., DIVISION ENGINEER, NEW CROTON AQUEDUCT, NEW YORK CITY. New York ; John Wiley & Sons, 15 Astor Place (price, $5).

The great masonry dams of the world have been mainly built within the last 20 years, and few of them are described in existing works on engineering. Mr. Wegmann's monograph, therefore, fills a gap in engineering literature, and will be very acceptable to those who are interested in the subject. It is based upon the investigations undertaken in connection with the plans and calculations made for the proposed Quaker Bridge Dam, which is to be 270 ft. high, and is to form an immense storage reservoir for the water supply of the city of New York. This will be the highest dam in the world, the nearest to it now in existence being the Furens Dam in France, 171 ft., and the San Mateo Dam in California, 170 ft. high.

The book contains descriptions of a number of masonry dams in this and in foreign countries, and is accompanied by a number of tables giving the details of these structures in a condensed form. There are also a number of plates, giving profiles and other figures in relation to them.

The preface to the book states the motive for its issue as follows : "While the practical importance of the subject of masonry dams seems to be steadily growing, the engineer who may be entrusted with the design of such works will find the theoretical study of the best form of

profile for a masonry dam very disheartening. How widely the types proposed by eminent engineers differ from each other is shown in our frontispiece.

"The theory of masonry dams is based upon a few simple principles and conditions ; the mathematics, however, to which they give rise, when applied to the design of an economical profile, are rather appalling. Thus, if we follow the methods of the French engineers, Sazilly and Delocre, we have to solve lengthy equations, some of them of the sixth degree. Moreover, there is always an uncertainty which equation is to be used, and the only way of determining this is by trial. If we wish to employ the method of Professor Rankine, but change the data assumed by him, we have to make trials with the subtangent of a logarithmic curve. In contradistinction to these scientific methods, we find prominent engineers recommending trial calculations as the best practical solution of the problem.

"The writer, . . . after studying the existing methods of designing profiles and finding them for various reasons inapplicable to the case in view, finally arrived at the equations given in this book. They are easy to solve, being, with the exception of one cubic equation, of the first or second degree. The theoretical section of the Quaker Bridge Dam was calculated by these equations."

The book may be accepted as a valuable contribution to engineering literature, in a field heretofore almost unoccupied, and the facts and theories presented are worth careful study.

ABOUT BOOKS AND PERIODICALS.

THE AMERICAN PEOPLE is the title of a new journal which is to be published weekly in Pittsburgh by the National Iron & Steel Publishing Company. The object of the paper is to advocate the continuance of the protective tariff system in the United States. The first number presents an attractive appearance ; it is well printed, well edited, and contains a variety of matter calculated to appeal to and attract readers of all classes.

The first of the series of railroad articles in SCRIBNER'S MAGAZINE appears in the June number, and is on the Building of a Railway, by Thomas Curtis Clarke. Mr. Clarke's article gives a general description of the methods used in the location and building of a railroad, and is also largely historical, relating what has been done in the past, and giving some instances of the difficulties encountered and overcome in the construction of railroads. It contains a large number of illustrations, some of which are very well done, and give striking examples of railroad work.

The next article—on Engineering Feats—which will appear in the July number, will be by Mr. John Bogart.

In NEW YORK RAILROAD MEN for May is begun a series of articles on the railroad books in the Railroad Men's building at 361 Madison Avenue. The first one, on General Works, by James Egan, is brief, as general works on railroads are few. The mechanical and technical works will be discussed in the next issue of the paper, in June.

The article on "What to Read" ought to serve as a guide to the uninitiated ; the article on "Books and Character" impresses us with the fact that "Man's character is very largely shaped by the books he reads," and that the man who reads on railroading will become a valuable man to the company.

Among the new books now in preparation by Messrs. John Wiley & Sons which will shortly be published are : A TREATISE ON HYDRAULICS, by PROFESSOR MANSFIELD MERRIMAN, which is designed both for the use of engineers and as a text-book for technical schools ; DESCRIPTIVE GEOMETRY, by PROFESSOR SOLOMON WOOLF ; ROCKS AND SOIL : A TREATISE ON THE CHEMISTRY OF GEOLOGIC TRANSFORMATIONS AND SOIL COMPOSITION, by DR. H. E. STOCKBRIDGE, of the Japanese Imperial College of Agriculture ; MICROSCOPIC PHYSIOGRAPHY OF MINERALS AND ROCKS, by PROFESSOR H. ROSENBUSCH, translated by JOSEPH P. IDDINGS of the United States Geological Survey. This last-named work will be profusely illustrated.

LIEUTENANT BRADLEY A. FISKE, who is well known to our readers, has a paper in a recent number of the *Army and Navy Journal* on the use of electric motors for naval and military purposes. Lieutenant Fiske presents very strongly the advantages of electric motors for use in ships and forts over steam engines ; and also over pneumatic and hydraulic engines, claiming that they are more simple, more quiet, more clean, require less attention, and are more easily controlled ; moreover, wires take less room than steam or water pipes on board the ship, and being very much smaller than pipes are less liable to be struck, while they have the further advantage that if an electric wire should be cut by a shot it can be very quickly and easily repaired, and there will be no escape of steam or water, as when pipes are broken. There is a still further advantage that, with a central dynamo with main wires leading through the ship or fort, small motors for different purposes, such as hoisting ammunition, working guns, etc., etc., can be placed wherever they are most convenient for use and can be worked from a central station. Lieutenant Fiske presents his arguments admirably, and his paper is well worth reading.

An INDEX OF ENGINEERING ARTICLES contained in leading periodicals for the five years 1883–87, inclusive, has been prepared by Mr. Francis E. Galloupe, M.E., who purposes publishing it, provided a sufficient number of subscribers can be obtained. The periodicals included in *Index* are : *Engineering News ; Iron Age ; Mechanics ; American Engineer ; Engineering and Building Record ; Railroad Gazette ; Van Nostrand's ;* RAILROAD AND ENGINEERING JOURNAL ; *Journal of Franklin Institute ; Street Railway Gazette ; Electrician ; Electrical Review ; Electrical World ; Scientific American Supplement ; The Locomotive ; Society of Arts Proceedings ; Engineering* (London) *; The Engineer* (London).

Mr. Galloupe's prospectus says : "The work, which is now ready for the press, contains upward of 10,000 carefully selected references, arranged in a single alphabetical index by subjects, covering information now only to be extracted by the aid of some 150 different indices, and is designed to make accessible to engineers in all branches of the profession, to special investigators, librarians, editors and others, such information without loss of time."

There can be no question that such a work will be of very great service to engineers. Much of the best engineering literature is contained in the various periodicals, and it is often a work requiring so much time to hunt up the article wanted that it is practically impossible to do it. The cost of the *Index* will be $2, and persons wishing to

subscribe can address Mr. Galloupe at No. 30 Kilby Street, Boston.

BOOKS RECEIVED.

Some Thoughts and Suggestions on Technical Education: by Professor T. Egleston, Ph.D. New York; published by the Author. This is a reprint of the Presidential address made by Professor Egleston before the American Institute of Mining Engineers at the Boston meeting in February last.

Steam and its Rivals: by Professor R. H. Thurston. Reprinted from the *Forum*.

Institution of Mechanical Engineers: Proceedings, February, 1888. London, England; published by the Institution.

Report on the Relation of Railroads to Forest Supplies and Forestry, with Appendices on the Structure, Behavior, and Causes of Decay of Some Timber Ties; on Wood Preservation; on Metal Ties; and on the Use of Spark Arresters: Compiled by the Chief of the Forestry Division, Department of Agriculture. Washington; Government Printing Office.

Internal Commerce of the United States: 1887. Special Report on the Commerce of the Mississippi, Ohio, and Other Rivers, and of the Bridges which Cross them. William F. Switzler, Chief of the Bureau of Statistics, Treasury Department. Washington; Government Printing Office. This is Part II of the report on Commerce and Navigation for 1887.

Transactions of the American Institute of Mining Engineers: Boston Meeting, February, 1888. New York; issued by the Institute.

Some Applications of Graphical Statics: by James R Willett. Chicago; *Inland Architect* Press. This is a reprint of a very interesting paper read before the Chicago Chapter of the American Institute of Architects by the Author.

Fifth Annual Report of the Board of Railroad Commissioners of the State of New York, for the Year Ending September 30, 1887; Volume II: William E. Rogers, Isaac V. Baker, Jr., Michael Rickard, Commissioners. Albany, N. Y.; State Printers.

Eleventh Annual Report of the Railroad Commissioner of the State of Virginia, for the Year 1887: J. C. Hill, Commissioner. Richmond, Va.; State Printing Office.

Steam Boilers Practically Considered. St. Louis, Mo.; issued by the Pond Engineering Company, No. 707 Market Street.

Papers Read before the Engineering Society of the School of Practical Science, Toronto: Number 2. Toronto, Ont.; printed for the Society. This, the second yearly number, contains papers on Rodding on Railroad Work, by G. H. Richardson; Explorations on Battle River, by H. G. Tyrrell; Mortars and Cements, by A. L. McCulloch; Railroad Surveys, by A. R. Raymer; Petroleum, by W. J. Withrow; Notes on Iron Bridge Building, by E. W. Stern; Angle Blocks, by T. K. Thomson; Transition Curves, by J. L. Allison.

Occasional Papers of the Institution of Civil Engineers. London, England; published by the Institution. The present installment of these papers includes the Castletown Swing Bridge, by Charles Wawn; the Alexandria Dock, Hull, by Arthur Cameron Hurtzig; a Covered Way, as Constructed on the Glasgow City Railway, by Walter Stuart Wilson; the Electrical Tramway in Hamburg, by J. L. Huber; Use and Testing of Open-hearth Steel for Boiler Making, by Hamilton Goodall; Autographic Drifting Tests, by John Goodman; Experiment with a Steam Exhauster or Blower, by George Brunton; the Hooghly Jubilee Bridge, by Sir Bradford Leslie; Improved Systems of Chaining for Surveys, by William Mann Thompson.

An additional installment of these papers received includes the following: River Gauging at the Vyrnwy Reservoir, by John Henry Parkin; Classification of Continuous Railway Brakes, by Arthur Wharton Metcalfe; Alignment of the Nepean Tunnel, New South Wales, by Thomas William Keele; Mining Appliances in Westphalia, by MM. Malhet, de Gournay, and Suisse, translated by William Silver Hall; Heating Carriages by Exhaust Steam on the Caledonian Railway, by Dugald Drummond; Boiler Experiments and Fuel Economy, by John Holliday; Economic Use of the Plane Table in Topographical Surveying, by Josiah Pierce, Jr.; Dipping or Fog Apparatus for Electric Light in Lighthouses, by Charles Alexander Stevenson; Abstract of Papers in Foreign Transactions and Periodicals.

Annual Report of the Secretary of Internal Affairs of the Commonwealth of Pennsylvania: Part IV: Railroad, Canal and Telegraph Companies, for the Year 1886. Thomas J. Stewart, Secretary. Harrisburg, Pa.; State Printer.

The Designing and Construction of Storage Reservoirs: by Arthur Jacob. Revised and Extended by E. Sherman Gould. Science Series, No. 6. New York; D. Van Nostrand, 23 Murray Street. (Price, 50 cents.)

American Street Railway Association: Report of the Sixth Annual Meeting, held in Philadelphia, October 19 and 20, 1887. Brooklyn, N. Y.; issued by the Association; W. J. Richardson, Secretary.

The American Economic Railway, Mansfield System (Gauge 2 ft.): by George E. Mansfield. Boston, Mass.; published by the Author.

The Official Railway List: 1888. Chicago, Ill.; published by the Railway Purchasing Agent Company, No. 95 Adams Express Building. This is the seventh year of this very useful publication, which is a directory of the railroad officers of the United States and Canada, corrected yearly.

Combinations: their Uses and Abuses; with a History of the Standard Oil Trust: by S. C. T. Dodd, Solicitor of the Standard Oil Trust. New York. This is a reprint of the argument made by Mr. Dodd before the Committee of the New York Senate, in relation to bills pending before the Legislature.

Automatic Fire Sprinklers: A Text Book. New York; issued by the Edward Barr Company, Limited, No. 78 John Street.

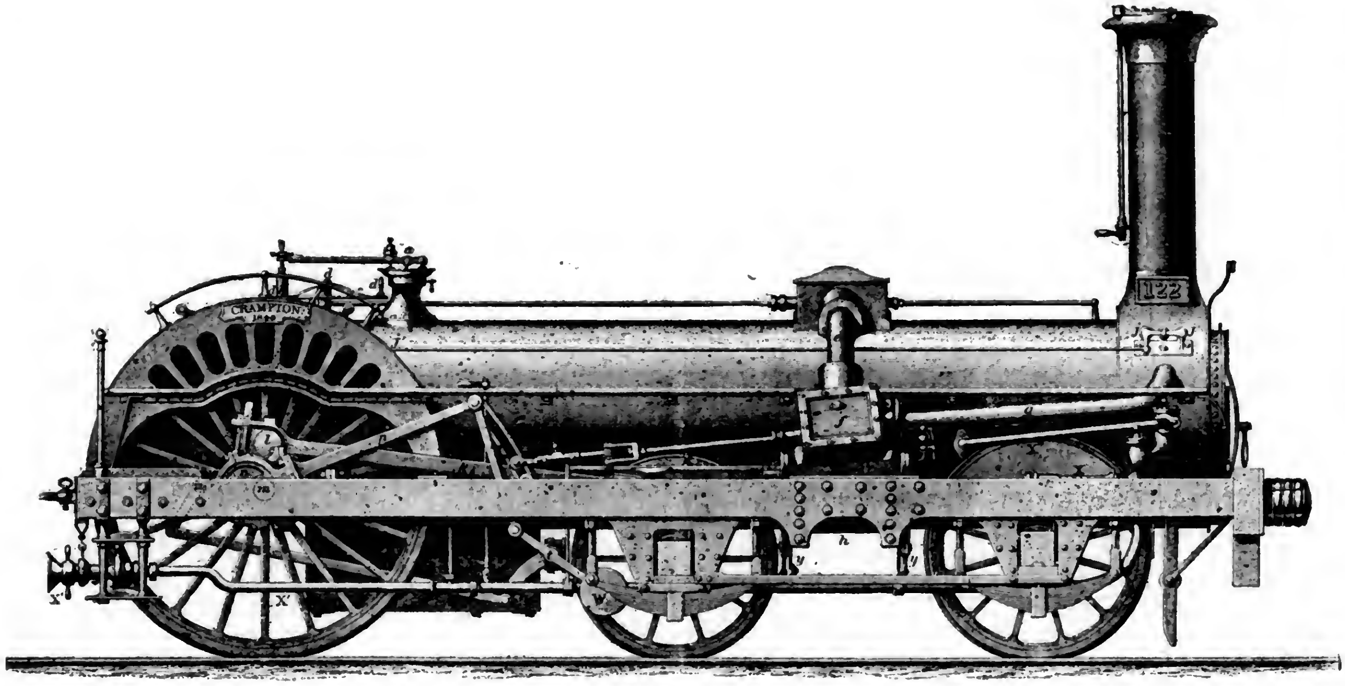
Automatic Cut-off Steam Engines: Catalogue. Erie, Pa.; issued by the Erie City Iron Works.

VREELAND'S PATENT TRANSFER JACK: CATALOGUE AND DESCRIPTION. New York; Watson & Stillman, 210 East 43d Street. This is a description of a very handy jack intended for use in round-houses and erecting shops.

CHALLENGE EMERY GRINDING AND POLISHING MACHINERY: CATALOGUE. New York; issued by the Prentiss Tool & Supply Company, No. 42 Dey Street.

The Crampton Locomotive.

THE recent death of Mr. Thomas Russell Crampton recalls attention to the Crampton locomotive, which was designed some 40 years ago for fast passenger service, and of which high expectations were then entertained. It may therefore be of interest to our readers to recall what were the characteristics of this engine.



THE CRAMPTON LOCOMOTIVE.

As shown in the accompanying illustration, which is reproduced from an old engraving, the distinguishing features of the Crampton engine were a long boiler, very large driving-wheels, and a low center of gravity. To secure the last-named object outside cylinders were used, and all the valve gear was also placed outside, the boiler being brought down as close to the axles as possible.

This engine was much discussed in England, but was never adopted to any considerable extent on the railroads of that country. Where it did come into use its obvious disadvantages as a locomotive for heavy work led to its gradual abandonment as passenger service grew harder, and it has been replaced by engines which have gradually approached the American type.

In France, however, the Crampton engine was adopted by several of the great railroad companies and was extensively used. While it has, in that country also, passed out of use to a considerable degree, its influence is still perceptible in the general design of the passenger engines in service on French railroads.

Modern practice favors only one point of Mr. Crampton's design, the outside cylinders, and the engine is now of interest chiefly to show what was considered desirable by an engineer of high repute in the earlier days of railroads.

Pope's "Flying Pendant Lever Bridge."

To the Editor of the Railroad and Engineering Journal:

In your May number I note a review of the "Treatise on Bridge Architecture," by T. Pope, 1811. You say that you "are not aware that Mr. Pope's arguments, however, were successful in convincing the capitalists of his day, and, so far as we know, no bridge on the 'Flying Pendant Lever' plan was ever actually constructed, even on a small scale."

This is hardly fair treatment of Mr. Pope. Turn to page 278 of his treatise, and read the description of the "Grand Model" actually built, a half-bridge on a scale of $\frac{3}{8}$ in. to one foot: "The length of model of half-bridge, in real measure, is nearly 50 ft. The weight that the unsupported arm of this diminutive model bore at one time, since finished, has been 10 tons."

Have we an engineer to-day who, with Mr. Pope's material and facilities, can do better? I trow not. Our improvement since that date has been more in metallurgy than in men.

The writer knows one eye-witness of the "Grand Model" whom he believes to be still living in Hoboken, and who described the model clearly, but could not tell the name of the man who made it.

Such is fame. ALOHA VIVARTTAS.

New York, May 3, 1888.

[It was not intended to deprive Mr. Pope of any credit justly belonging to him. The statement made in the article to which Mr. Vivarttas refers was intended to apply to bridges built for actual service. Mr. Pope was probably in advance of the age in his theories, though somewhat lacking, apparently, in practical experience.—EDITOR RAILROAD AND ENGINEERING JOURNAL.]

THE PRINCIPLES OF RAILROAD LOCATION.

By Professor C. D. Jameson.

(*Continued from page* 205.)

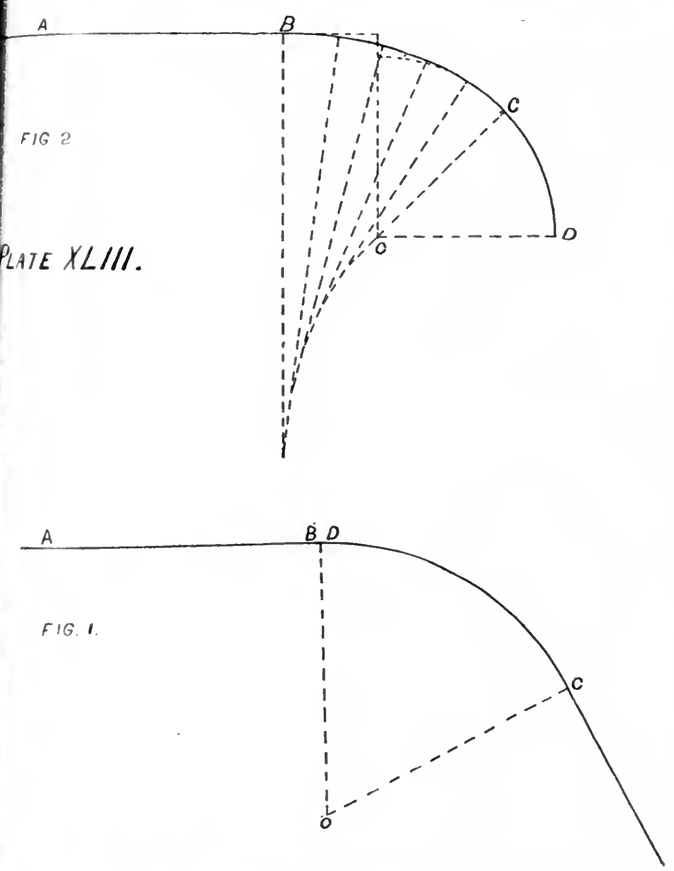
CHAPTER XXI.

TRANSITION CURVES.

The object of the use of TRANSITION CURVES in locating and building a line of railroad is to make the change in direction from a straight line to a curve of a given radius less abrupt and sudden than when the required curve joins directly with the straight line.

This is accomplished by leaving the straight line on a curve whose radius approaches infinity, and gradually decreasing this radius until it becomes equal to the radius of the required curve.

Thus, in Plate XLIII, fig. 1, let *A B* be the tangent and *D C* the required curve. When *D C* joins the tangent at



B, the change of direction is more or less abrupt, depending upon the radius of the curve *D C*.

This change of direction is very perceptible in a train running at a moderate or high rate of speed, and produces a certain amount of wear and tear on the rolling stock and track and also increases the amount of resistance opposed to the movement of trains.

Transition curves do away to a great extent with this jar given to trains, and the wear and tear to rolling stock and track, and to some extent reduce the resistance due to the curve, thus diminishing the evil effects of curves and permitting the use of curves of a shorter radius.

Moreover, by the use of transition curves a railroad line can be fitted much more accurately to the ground, as the contour of hills, etc., and the general configuration of the ground are found in most cases to change gradually and therefore to conform more nearly with a line made up of tangents, transition curves, and circular curves than one where the required circular curve is joined directly to the tangent. In Plate XLIII, fig. 2, let *A B* be the tangent and *C D* the required curve; then in place of joining the curve directly upon *A B*, we leave *A B* with a curve whose radius approaches infinity, and as we approach *C* we gradually decrease this radius until some point *C* is reached where the radius of this transition curve equals the radius of the required circular curve *C D*.

The circular curve *C D* is then run in for the required distance and joined to the following tangent by means of another curve similar to *B C*.

The curve *B C* which most nearly approaches the one required by theory for the transition curve is the cubic parabola and some spirals that nearly coincide with it.

Now, in order to make these curves of practical use, it must be possible to run them in in the field with no more difficulty than an ordinary circular curve, and this to a certain extent is not possible when the cubic parabola or spirals are used.

The whole principle of the transition curve is as follows: In Plate XLIV, let *A B* be the tangent and *D E F* the required circular curve.

Now, what is done in reality, no matter what method, formula, or curve is used, is that the curve *D E F* is moved in a certain distance, *D B*, from the tangent or the radius of this curve shortened by the distance *D B*; that *B*, the point of tangent (P. T.), is moved back from *B* to *A* a certain distance, and that the part *D E* of the circular curve is replaced by *C E* of the transition curve, the transition curve passing through the point *C*, which is half-way between *B* and *D*.

In using the cubic parabola or a spiral, the distance *D B* is determined by the radius of the curve *D E F*, and cannot be changed unless the spiral is changed, which necessitates either a great number of tables or a long complicated calculation with each curve, which is not admissible in the field.

When any method is used which absolutely fixes the length of the offset *D B*, the line when run in on the ground is as rigid and unyielding as if no transition curve had been used—that is, no part of it can be moved to fit it more closely to the special formation of the ground at that point without the preceding and following portions of the line also being changed, thus necessitating much additional work, and in the end a much less accurate fitting of the line to the ground.

Therefore another object to be sought for by means of the transition curve is the rendering of the line *elastic* to a certain extent—that is, so arranging the connection between the circular curve and the tangent by means of the transition curve, that the circular curve *D E F* can be moved back and forth to one side or the other (always, of course, within certain limits) and the connection between it and the tangents still be accurately made without in any way affecting the position of the tangents more than increasing or decreasing their lengths to a slight extent, as the case may be.

The following method, although it may appear crude, and certainly is not theoretically correct, is accurate enough for all practical purposes, and has the advantage over all others known to the author of making an elastic line

which may be fitted accurately to the ground and any part of it changed at any time within certain limits without necessitating the changing the location of any other part of the line.

The offsets *B D* of the circular curve from the tangent are taken anywhere from 4 ft. to 20 ft., or even a greater distance, if necessary.

In Plate XLIV let *A B* be the tangent and *D B* any desirable offset (its length depending upon the contour of the ground in each particular case) of the circular curve *D E F* from the tangent. The transition curve connecting the tangent and this circular curve must pass through the point *C*, half-way between *B* and *D*. Then the conditions necessary, for a transition curve are complied with, with all necessary accuracy, by introducing a curve *A h C m E*, to which *A B* shall be tangent, which shall pass are 100 ft. or 200 ft. from *C* either way, and the offset is always measured toward the outside of the curve, as *g h* and *n m*. The distances *A B* and *D E* have been considered equal. This is not actually the case, however, *A B* being nearly equal to *C E*, and *C E* a trifle longer than *D E*. The difference, however, is so slight that it may be entirely disregarded. Within the limits laid down in the table, the greatest difference between *A B* and *D E* is when the circular curve is 16° 30′ and the offset *D B* 20 ft., and even in this case it is only 2 ft., which distance would not in any way affect the practical accuracy of the curve *A g C m E*.

The manner of running in these curves is as follows: The tangent *A B* is run up to any point, as *B*, where, from the configuration of the ground, it is deemed advisable to introduce a curve.

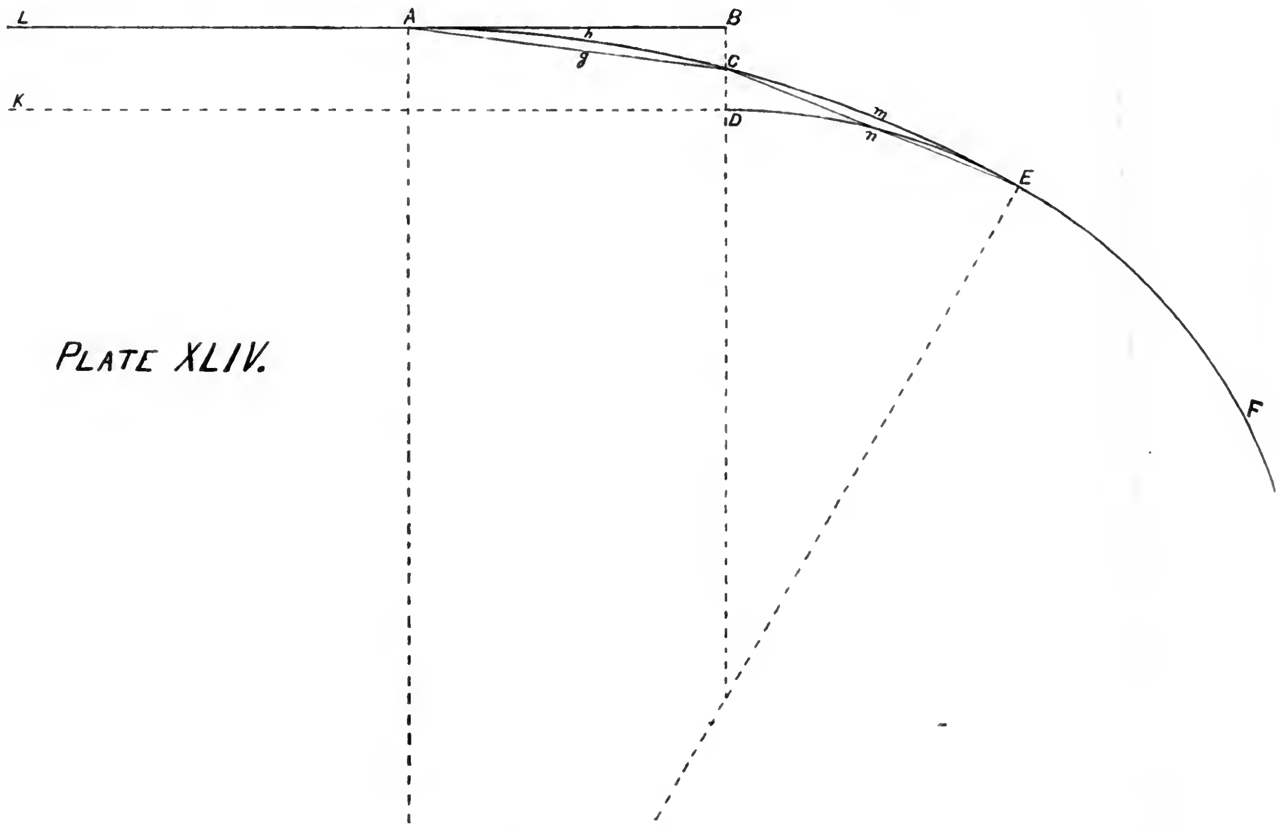


PLATE XLIV.

through the point *C* ($CD = \frac{1}{2} BD$) and which shall be tangent to the circular curve *D E F*.

The curve *A h C m E* is not, of course, a theoretical transition curve; it is of the same radius throughout, and is simply a curve with a radius larger than that of the circular curve, and connecting the circular curve with the tangent.

The accompanying table (which is numbered as Plate XLV) contains all the required data for running in transition curves of the above-mentioned type. In this table column 1 contains the degree of curvature of the circular curve, the chords subtending this angle being 100 ft. long.

Column 2 contains the radii of the curves.

Columns 3, 5, 7, 9 to 19 contain the distances *A B* and *D E* (Plate XLIV) for curves of different radii and offsets of different lengths. The numbers at the head of the columns are one-half *D B* or *C B*.

Columns 4, 6, 8, 10 to 20 contain the offsets from the chords *A g C* and *C m E* connecting the points *A C* and *C E*.

The points on the chords where these offsets are taken

The radius of the curve and the offset *D B* which will best fit the ground are decided upon.

The distance *D B* is measured and stakes put in at *D* and *C*; then a sufficient distance back on the tangent to afford a good back-sight, as at *L*, a distance, *L K*, equal to *D B*, is measured off and a stake put in with a tack point.

The transit is set up at *D* and sighted on *K*, the telescope then reversed and the circular curve run in. This curve is continued until it is deemed necessary to run off on a tangent, when *any* required offset is taken and the tangent run in. Until the line is being staked out for construction to commence there is no absolute need of running in the transition curves. When, however, it is desired to put them in we find in column 1 of the table the degree of curvature of the circular curve. Then following this row of figures across the page until we come to the vertical column which has $C\,D = \frac{1}{2}\,B\,D$, $B\,D$ being the offset from the tangent which has been taken, and in this column and opposite the radius we will find the transition distances *A B* and *D E* in feet. This distance is

PLATE XLV.

TABLE FOR LAYING OUT "TRANSITION CURVES," WITH OFFSETS OF DIFFERENT LENGTHS, WITH CIRCULAR CURVES OF DIFFERENT RADII.

(Letters of reference in this Table refer to Plate XLIV.)

1. Degree of Curvature.	2. Radius.	3. c d 2.	4. m n or g h.	5. c d 3.	6. m n or g h.	7. c d 4.	8. m n or g h.	9. c d 5.	10. m n or g h.	11. c d 6.	12. m n or g h.	13. c d 7.	14. m n or g h.	15. c d 8.	16. m n or g h.	17. c d 9.	18. m n or g h.	19. c d 10.	20. m n or g h.
3°	1,910	123	0.3	151	0.7	175	1 0	196	1.2	214	1.5	231	1.7 0.8	247	1 9 1.3	262	2.1 1.6	277	2.3 2.0
3° 30′	1,637	114	....	142	0.6	162	0.9	181	1.2	198	1.5	214	1 7 0.4	229	2.0 •.9	243	2.2 1.2	256	2.4 1.8
4°	1,433	107	....	131	0.5	151	0.9	169	1.2	185	...	200	1.7	214	2.0	227	2.2 1.0	240	2.4 1 4
4° 30′	1,273	101	0.2	123	0.4	143	0 8	160	1 1	175	1.5	189	1.7	202	2.0	214	2.2	226	2.4 1.2
5°	1,146	96	....	117	....	135	....	151	1.1	166	....	180	1.7	192	2.0	203	2.2	214	2.5 0.8
5° 30′	1,042	91	...	111	0.2	129	0.7	144	....	158	1.4	171	1.7	183	2.0	194	2.2	205	....
6°	955	87	....	107	....	124	....	139	1.0	152	1.3	164	1.6	175	....	186	....	196	2.5
6° 30′	881	84	....	103	....	119	0.6	133	....	146	....	157	.. .	168	1.9	178	2.2	188	2.5
7°	819	81	....	99	0.2	115	....	128	0.9	140	1.2	151	1.5	162	1.8	172	2.2	181	2.5
7° 30′	764	78	....	96	....	111	0.3	123	....	135	..	146	....	157	....	166	....	175	....
8°	716	76	....	93	.. .	107	....	119	0.7	131	1.0	142	....	152	1.7	161	2.1	170	2.4
8° 30′	674	73	....	90	....	104	....	116	....	127	....	138	1.4	147	....	156	....	165	....
9°	637	71	....	87	...	101	0.1	113	..	124	....	134	....	143	....	152	2.0	160	2.3
9° 30′	603	69	....	85	....	98	....	110	0.4	121	0.8	131	1.2	139	1.6	148	....	156	....
10°	574	68	....	83	....	96	....	107	....	118	....	128	....	136	....	144	....	152	2.2
10° 30′	546	66	....	81	. ..	93	....	104	....	115	....	124	...	133	...	141	1.8	148	....
11°	522	65	...	79	...	91	....	102	....	112	....	121	0.9	130	1.4	138	...	145	....
11° 30′	499	63	....	77	....	89	....	100	0.2	110	0.5	118	....	127	....	135	.. .	142	....
12°	478	62	....	76	....	88	....	98	...	108	..	117	....	124	....	132	....	139	2.0
12° 30′	459	60	....	74	....	86	....	96	....	105	....	114	...	121	....	129	1.6	136	...
13°	441	59	....	72	...	84	....	94	....	103	....	111	....	119	1.1	127	....	134	....
13° 30′	425	58	....	71	....	82	....	92	....	101	....	109	0.6	117	....	124	....	131	1.8
14°	410	57	...	70	...	81	....	91	....	99	0.2	107	....	115	....	122	....	129	....
14° 30′	396	56	.. .	68	....	79	....	89	....	97	....	105	....	113	....	120	1.2	127	...
15°	383	55	....	67	. ..	78	....	88	....	96	....	104	....	111	0 6	118	....	125	..
15° 30′	370	54	....	66	....	77	....	86	....	94	...	102	....	109	....	116	....	123	....
16°	359	54	....	66	....	76	....	85	....	93	. .	101	....	1c8	.. .	115	....	121	1.4
16° 30′	348	53	....	65	....	75	.. .	84	....	91	....	100	0.3	106	0.3	113	•.7	119	1.4

measured back from B to A and a stake put in ; it is also measured forward from D to E, the stake E being lined in with the transit, so as to be in the curve $D\ E\ F$.

In the next column to the right of the one containing the transition distance will be found the offsets from the chords $A\ g\ C$ and $C\ n\ E$ to the curve $A\ h\ C\ m\ E$.

Measure from the point C 100 ft. each way, and line these two points in by the eye, and then from the points thus found, and as near at right angles as may be, measure off the distance of the offset as given in the table under $m\ n$ and $g\ h$, and put in a stake at h and m. When the transition distance is more than 200 ft., the table contains two offsets—one 100 ft. from C and the other 200 ft.

At any time the position of the curve or the tangents may be changed within certain limits without changing any other part of the line.

1. The radius can be shortened until the actual length of the curve is equal to the transition distance $D\ E$ at one end, *plus* the transition distance at the other.

2. The radius can be increased until the offset $B\ D$ becomes 4 ft., unless the radius is equal to or greater than 1,910 ft., when it can be increased until $D\ B = O$ and D coincides with B and all necessity for a transition curve is done away with.

3. The curve or the tangent can be moved in any direction, provided always the distance $D\ B$ at either end of the curve does not become less than the minimum distance allowed, or that the transition distance $D\ E$ at one end of the curve *plus* $D\ E$ at the other end of the curve does not become greater than the total length of the curve.

CHAPTER XXII.

GRADES.

One thing, above all others, upon which depends the future success of a railroad, from a financial standpoint, is the economical establishment of the GRADES in detail. This, of course, is determined to a great extent by the character of the country through which the railroad is to be built, but in any class of country and whatever the surface and profile that a line may have, there is always one system of grades which is pre-eminently better than any other, and it is the duty of the engineer to find that system.

The GRADES of a road are usually of much more importance than the CURVES. This is not due to any inherent evil in the grades themselves, but rather to the fact that, owing to the configuration of the country, the grades limit the amount of load that can be hauled by one locomotive. That is, the resistance due to the grade is the limit of the amount of work which can be done by one locomotive. Of course, if the configuration of the country should be

such that the resistance due to the curves exceeds that due to the grades, then the resistance due to the curves becomes the limiting power, and the general order of things is reversed. To the knowledge of the writer, however, there is only one railroad in the United States in which this happens; that is the Hudson River Railroad, where, owing to the exceptional character of the country, the curves are of necessity very sharp and the grades comparatively nothing, so that the resistance due to the curves far exceeds that due to the grades, and the curves become the limiting element of the amount of work that can be done by a locomotive. This resistance due to the grades is not in itself so bad, but is bad simply from the fact that, as the locomotive is now built, the limit of its power, and thus the limit of the possible load, is very soon reached; but if the time ever comes that some new motive power is discovered by means of which the power can be greatly increased when necessary and not lost when unnecessary, then much of the present evil due to grades will be done away with.

Before going into the question of the rate of grade and the economical problems concerning the future operating expenses, we wish to call attention to some considerations in regard to the cost of construction. It is stated by most writers that the grade line should be such that the cuts will balance the fills, so that the material excavated will serve to make embankments, but there are many things to be considered in this connection.

In Plate XLVI, fig. 1, let *A* represent a cut and *B* a fill. Where the land is of little value and material may be obtained without paying any land-damages for earth borrowed from the side of the line, then the cost of the haul from *A* becomes very soon greater than the cost of loosening and hauling from the side of the fill, and it is economy to waste the excavation and make the embankment *B* from material borrowed from the side. Where the land is valuable, in a thickly settled country, the economical length of the haul will be much greater. As the length of the haul increases the cost of excavation increases very fast, and very soon exceeds the cost of wasting the excavation and borrowing the material to make the fill. Of course the question of the cost of wasting and borrowing, as compared with making the fills from the excavation, is more properly a question to be studied in detail under the head of construction, and the locating engineer has only to consider it in its larger and more general features.

This question must be studied with care in each case, and will be taken up more in detail in a chapter on the Calculation and Estimate of Earth-work.

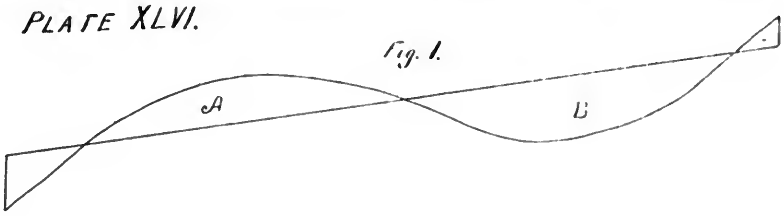
CHAPTER XXIII.

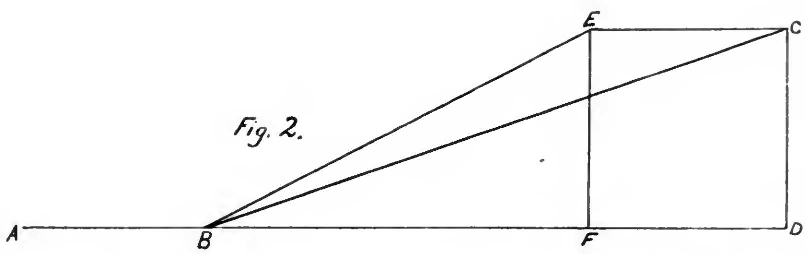
RATE OF GRADE.

By the RATE OF GRADE is meant the angle which the grade line of a road forms with the horizontal. This angle is very seldom given in angular measurement—that is, in degrees and minutes—but usually in so many feet of vertical rise to a certain length horizontal. Thus it may either be given in so many feet rise to 100 ft. horizontal, as a grade 4 ft. rise to 100 ft. horizontal, or a 4 per cent. grade, as it is called, or as so many feet to the mile, as 52.8 ft. rise per 1 mile horizontal—that is, a 1 per cent. grade. English engineers very often give it in the shape of 1 ft. rise to so many horizontal, as 1 ft. in 80 or 90 ft.—that is, 1 ft. rise to 80 or 90 ft. horizontal. There are very many objections to this last method, and by far the best way is to give it in so many feet to the hundred or its per cent.

As we have stated before, the grades are of much more importance to a road than the curves, as they constitute the limiting power as to the amount of work which can be done by one locomotive. Another reason for their superior importance over curves is that any increase in length of line due to curvature is not an entire loss to the railroad, as the public seem perfectly willing to pay an additional sum for being carried around a large curve where they would not pay a cent more for going up and down a steep grade which would save them distance, or through a costly tunnel or over an expensive bridge.

PLATE XLVI.





Some question has arisen on the above point, however, as, since the passage of the Inter-State Commerce Bill, one at least of the railroad companies between New York and Boston has been making efforts to charge more per mile for taking passengers and freight over an extremely costly portion of its road than the legal rate per mile over cheaper parts, thus making the mileage more on an expensive road than on a cheap road. As yet this question as to whether companies have a legal right to so charge for special or constructive mileage more than their actual mileage has not been decided.

The statement that either grades or curves act as the limit of the amount of work that can be done by one locomotive may be explained as follows: A locomotive can haul a certain number of loaded cars or a certain number of tons

on a straight and level track. Wherever a curve is introduced this curve presents a certain amount of resistance to the passage of a train, and consequently a locomotive which is worked up to its full power on a curve hauls less than its full load on a straight line, where the road over which it runs is made up of curves and tangents; the amount of power wasted on a straight road being equal to the amount of resistance due to the curve, provided the curve was equal in length to the tangent. Also, on a grade which presents a certain amount of resistance a locomotive can haul a certain number of tons, and when worked to its full power on the grade, of course the load is much less than can be hauled on a level track. On all the level track over which the engine pulls the train there is this amount of extra power lost. In other words, the evil due to both grades and curves is not so much in the actual power necessary to haul a given load over a grade or over a curve as it is the amount of power wasted in hauling this load over the straight and level track which alternates with the grades and curves in the line.

There is comparatively slight difference in the cost of running a locomotive working up to its full limit of power and one working only at half or quarter of its full power. So, in plain language, the loss to the road is not what the locomotive *has* to do on a grade or a curve, but what it *has not* to do on a level, straight track.

CHAPTER XXIV.

VIRTUAL LENGTH.

Now, from the notes of the preliminary survey we have a profile of the actual line run on the ground, and when an accurate contour map has been made of the belt of country through which this line passes, we are able to make approximate profiles of any desired line. In this way we are able to run, on paper, as many lines between terminal points as are deemed necessary and to make an approximate profile of each line. It is thus easy to see the great advantage and economy of having a correct contour map of the country. In some exceptional cases it is necessary to actually run several lines on the ground, but whether this is the case or not makes no difference so far as the question which we are now considering is concerned.

We have on paper the alignment and profile of what appear to be the best lines for the future road between terminal points. These lines may differ one from another in several ways. They may differ as to actual length, as to the number of degrees of curvature, and as to their grades or the number of feet of actual rise and fall in each. As to the difference in length, we will first assume this to be so slight as not to increase the actual number of stations, but simply to a slight extent the expense of doing the work. We will then examine differences so great as to actually increase the number of trains required, with all the expenses pertaining thereto, to do the same amount of work. On all the lines which we are to consider the amount of future traffic is taken as being exactly the same. Of course, in some cases it is possible to run several lines between terminal points, some of which will give more future traffic than others. When this is the case it simply presents another element which must be carefully studied and considered in the comparison of the lines, but at present we will simply assume the amount of traffic equal for all lines. The relative advantages of these lines to be compared are so slight that we cannot, by observation, decide which line is the best, and it is necessary, therefore, to institute an exact mathematical comparison.

In order that there may be no misunderstanding, we will state the proposition again. We will take two lines between the same terminal points, the amount of future traffic over each to be exactly the same, and every difference to be so slight as simply to increase the expense of doing the work without necessitating additional trains, stations, or employés of any kind. These lines may differ:

1. As to their length.
2. As to the amount of curvature, and
3. As to their grades, or the actual amount of rise and fall.

In order to compare these two lines we must reduce them all to some common standard, and this standard is a straight, level line—that is, a line without grades or curves, which is an ideal railroad line, so far as operating expenses are concerned.

This reduction of a given line to an ideal line may be made in terms of:

1. The amount of motive power developed, or,
2. In terms of the cost of operation—in fact, in terms of any element that enters into the running of trains or the preservation of the road-bed and superstructure.

In Europe this comparison is usually made in terms of the motive power developed, but in this country in terms of the operating expenses, and these last, or operating expenses, are what will be used here. Thus the actual lines with curves and grades will be reduced to level, straight lines of such length that it will cost exactly the same to haul the same train from one end of them and return, as it would cost to haul it over the actual lines with the curves and grades, considering not only the cost *per se* of running the train, but all the expenses of repairs, renewals, etc., both to the rolling-stock, road-bed, and superstructures.

The length of this ideal equivalent, straight, level line is called the VIRTUAL LENGTH of the actual line, and when the lines to be compared are thus reduced to their virtual lengths a simple comparison of these respective virtual lengths will at once give the relative economy and advantage of each line in regard to operating expenses.

The resistance due to the movement of the train is as follows:

1. The resistance due to friction of every kind, such as the rolling of the wheels on the rails, the journals in the boxes, and the resistance of the air. All of these resistances must be overcome by means of the motive power in order to run a train on a level and straight road.
2. The resistance due to grades which, in addition to the resistances encountered on a level, straight line, present the resistance of gravity on an inclined plane, due to the fact that the whole train is lifted bodily the vertical height which is overcome by the grade.
3. The resistance due to curves, which resistance is due to the increased friction between the flanges of the wheels and the rails, caused by the rails continually changing the direction of the train from the straight line which it would naturally follow to a curved line, and to the slipping of the wheels on the rails.

We always have the resistance due to the movement of the train on a straight and level line, and what we wish to find is exactly how much this resistance is increased by each foot of rise and fall and by each degree of curvature, and finally how much the operating expenses are increased by this increase of resistance; also how much the operating expenses are increased by a slight additional increase

in the length. The resistance opposed to the motion of a train on a straight and level line has been found to be about 9.3 lbs. per ton of train hauled. This amount varies, to a certain extent, with the attending circumstances in each case, and the various elements which go to make it up are too complicated and numerous to admit of a discussion of them here. One of these elements, for example, is the resistance of the atmosphere. This will vary in each particular case, changing according to the direction and force of the wind and the speed of the train. The total resistance of the train hauled varies with the length and weight of the train, the resistance due to moving a short, empty train being much greater relatively than that of a long, fully loaded one. The resistance also varies directly as the square of the speed. This being the case, we can only take the average resistance for an average train at an average speed. Therefore, we will assume the speed of the train to be about 15 or 20 miles per hour, and the resistance to be overcome 9.3 lbs. per ton of train hauled. The resistance due to grades or the increase of motive power necessitated by the presence of grades is simply the amount of power required to lift the train vertically the number of feet rise of the grade.

It takes, as we have assumed, 9 lbs. per ton to haul a train from A to B (Plate XLVI, fig. 2), and to haul it from B to C would take 9 lbs. plus the amount of power necessary to lift one ton vertically from C to D. When the grade that is being considered is not the ruling grade of the road, the rate of grade has nothing to do with the increased amount of power required. Thus it would take exactly the same increase in the amount of power required to move a train from B to C, or from B to E, or from B to F.

(TO BE CONTINUED.)

NOTES ON STEAM HAMMERS.

By C. Chomienne, Engineer.

(Translated from the French under special arrangement with the Author.)

CHAPTER I.

HISTORY OF THE HAMMER.

Before beginning this study we shall give a brief historical account of the direct-acting power hammer, in order to show clearly to the reader the progress which has been made in the construction of this tool from the date of its first invention.

The invention of the direct-acting hammer dates from the year 1840, and was not only a considerable event in itself, but was also the point of departure of a new era in metallurgical industry, the construction of large steam-engines and of the material for railroads. Without this tool it would have been impossible to forge the heavy pieces used in the construction of large marine engines; to forge in one piece the wrought-iron wheels used on locomotives and cars; to make the armor-plates of iron and steel which protect our war-ships, or the steel guns, the dimensions of which are every day increased.

Struck by the fact that the heaviest forge hammers in use about 1840 were insufficient in size to forge or to weld the shafts and cranks which were required in the construction of steam-engines, several engineers in France and in England, at about the same time, conceived the idea of suspending a mass of wrought or of cast iron from the piston-rod of a vertical steam cylinder, this block of iron forming a hammer, which was to be raised by means of steam introduced under the piston, and was then to be allowed to fall back upon the piece to be forged, conveniently placed upon an anvil. It appeared to them that this arrangement would enable them to vary the weight of the hammer, and the height of its fall within limits much more extensive than the existing hammer permitted.

Among these engineers, two men of great ability, both driven by the same necessity—James Nasmyth, in England, and François Bourdon, in France—followed up this idea, each on his own account, without knowing what the other was thinking of. Both had in view the same object of forging the heavy pieces for marine engines of a power greater than any which had been built previously to that time.

Nasmyth made a simple sketch of his idea in his sketch book, while Bourdon, who was then Chief-Engineer of the Creusot Works, made a detailed drawing of his steam hammer, which he executed in 1840, and for which MM. Schneider Brothers, proprietors of the Creusot Works, took a patent in their name, September 30, 1841. This design was shown to all the engineers who visited Creusot, and especially to MM. Mimeret, Bertrand, and Paulin, all three of them naval engineers, who were then in charge of the construction of marine engines which were being built for the State.

The sketch of Nasmyth's steam hammer bears the date of November 24, 1839, and it was also in 1839 that Bourdon had the idea of a direct-acting steam hammer, to which he gave the name of "Pilon," which the tool has retained to this day in France.

The sketch of Mr. Nasmyth was shown to Messrs. Humphries, Brunel, Guppy, and several other competent engineers, who approved the idea; but the marine engine for which the English engineer had specially conceived this idea, and fixed it on paper, was not built, and the invention remained on paper.

At this time, that is, in 1839, the idea of such a tool seemed so daring that the Schneiders hesitated for a long time before building one.

Toward the middle of 1840 MM. Eugene Schneider and Bourdon visited England in order to study and report on the best forge hammers there used, and it was during their visit to the Nasmyth Works that Mr. Gaskell, Mr. Nasmyth's associate—that gentleman being absent at that time—showed them the sketch of the hammer. This sketch being still incomplete in its details did not answer all of Bourdon's ideas, and he presented some objections, spoke of the hammer which he had designed in France, and drew with a pencil a sketch showing how, on his part, he had arranged the new machine.

After his return to France, M. Schneider, struck by the same idea which had presented itself at the same time to two men of distinguished merit, resolved immediately to put into execution the Bourdon plan of 1839. This hammer had been at work successfully for fifteen months when, in April, 1842, Mr. Nasmyth, on passing through Creusot, paid a visit to M. Bourdon, who asked him if he had put into practice his idea of the steam hammer. Nasmyth answered somewhat evasively, that he was studying out the machine and that he expected to build it very shortly. Bourdon showed him the design of the hammer, asking what he thought of the arrangements, and then invited him to walk into the shops and see it at work. When he saw it, Nasmyth stood still an instant, and then said to Bourdon: "I am delighted to see before my eyes what I have so long carried in my head."

It then appears that it was only after having seen the Bourdon hammer at work that Nasmyth returned to his sketch, and undertook the completion and execution of it, while the sketch shown to Bourdon by Gaskell did not at all change the plan which Bourdon had studied out before his visit to England. It must therefore be certainly admitted that the sight of the hammer at work at Creusot, and the confidence which Bourdon reposed in him by relating the difficulties encountered in working out the details of the machine, must certainly have fixed in Mr. Nasmyth's mind the idea which he had originally conceived.

The direct-acting hammer is thus really the invention of Bourdon; it is true that the English have tried to dispute his claim, but the facts abundantly prove the priority of the French engineer, while at the same time they do not really detract from the merit of his contemporary, James Nasmyth.

The first direct-acting hammer built at Creusot had a weight of 2,500 kilogrammes and a fall of two meters.

Since then these shops have built a great number of steam hammers applied to special work, and varying from time to time in form and dimensions.

La Compagnie des Fonderies et Forges de l'Horme has also made a specialty of the construction of these machines; it has furnished many of the establishments of the Loire with magnificent tools, which in skillful hands have produced some very remarkable forgings, and which bear witness to the enterprise of the makers and the excellence of their design.

In France the single-acting hammer is most generally used for forgings. In England the double-acting steam hammer has been employed, even for very large hammers, by many builders, such as Nasmyth, Wilson, and Thwaites. The last-named built for the Elswick Works of Sir William Armstrong a double-acting hammer of 35 tons; and a hammer, also double-acting, of 50 tons, for the Oboukoff Steel Works, near St. Petersburg.

In 1860 there was built at Creusot, for the forges of the Navy at Guérigny, a 20-ton* hammer.

In 1873, at the Vienna Exposition, there was shown a design for a 50-ton hammer built for the gun-factory at Perm, in Russia.

In 1878, at the Paris Exposition, the Creusot Works showed a model in wood of an 80-ton hammer, which was then under construction in the shops. The design of this hammer was subsequently modified, and its power increased from 80 to 100 tons.

In 1878 the Naval Steel Works, at St. Chamond, France, built an 80-ton hammer, intended, like that at Creusot, to forge heavy guns and armor-plates.

In 1885 the Société Cockerill, at Seraing, Belgium, built a 100-ton hammer intended for the Terni Steel Works in Italy.

In 1886, Marrel Brothers, at Rive de Gier (Loire), France, built two hammers, one of 50 and one of 100 tons.

The Bethlehem Iron Works, at Bethlehem, Pa., in the United States, are now building a 125-ton hammer intended to forge heavy shafts for marine engines and guns, armor-plates, and other war material.

CHAPTER II.

CLASSIFICATION AND PARTS OF THE HAMMER.

This study of steam hammers will include:

I. Single-acting hammers; that is to say, those in which the steam acts only upon one side of the piston, to raise the hammer; these are used chiefly to make the heaviest forgings, such as armor-plates, guns, shafts, crank-shafts, and axles for steam-engines or locomotives, die-work, and, in general, all mechanical forgings.

II. Double-acting hammers, whether automatic or not, in which the steam acts on both sides of the piston: 1. On the lower side to raise the hammer; 2. On the upper side to add its power or its force to that due to gravity alone.

III. Power hammers operated by compressed air, by springs, and finally those operated by belts.

I. Considering first the single-acting steam hammer, we now come to the study in detail of each of the parts composing a direct-acting hammer, which may be placed in the following order:

1. The foundations.
2. The bed-plates and sockets.
3. The legs or uprights; the frame.
4. The upper bed-plate or table.
5. The apparatus for distribution of steam.
6. The cylinders and arrangements for controlling the hammer action.
7. The pistons and piston-rods.
8. The hammer.
9. The holding dogs or safety-catches.

CHAPTER III.

THE FOUNDATIONS.

For small hammers in which the ratio between the weight of the working parts and that of the bed-plate is 1 : 10, and especially when the base has a wide surface, there is often used the method shown in fig. 1.

In the first place a bed of beton varying from 0.500 to 0.800 meter in thickness is put down; upon this mass there is constructed a box or trench of masonry, the interior dimensions of which are the same as those of the base of the bed-plate, and whose height varies from 1.000

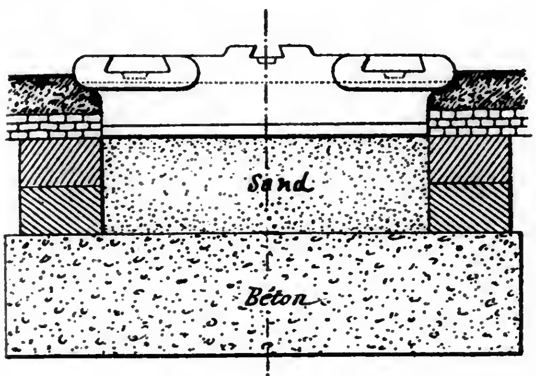


Fig. 1.

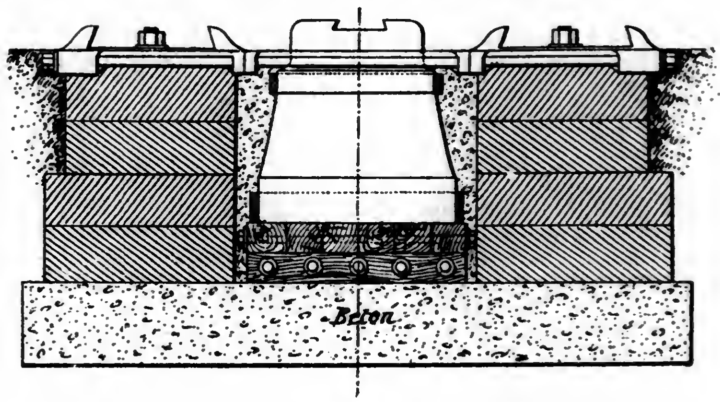


Fig. 2.

to 1.500 meters. This gap is filled with clean river sand, slightly damp, which is rammed down hard in layers of from 0.100 to 0.150 meter thick at the outside. This plan has the advantage of not costing very much and of making it easy to reset the hammer in case it should get out of line; for that purpose it is sufficient to raise the bed-plate a little and to work in sufficient sand to restore it to a horizontal position. This system, however, should only be employed where the hammer is some distance from the furnace, because otherwise, under the action of the heat, the sand will dry more on the side toward the furnace and will sink down unevenly and thus occasion frequent changes of level.

For the foundations of a larger hammer more care must be taken. It is necessary to study first with care the nature of the soil on which it is to be placed, for it is this which will determine, to some extent, the system of foundations which should be adopted; this done, it only remains to make judicious choice of the materials to be employed, and to watch with care the execution of the work.

A pit for the bed of beton should be dug out until the rock or a solid foundation is reached, and the bottom of this pit should be perfectly level; in case the subsoil is light and does not present sufficient firmness, it would be necessary to drive piles.

The hole dug for the foundation is filled with a bed of beton, mortar, and hydraulic cement, and on this bed, the thickness of which varies from 0.800 to 2.000 meters, according to the depth of the rock below the surface, there is placed a bed of masonry of large cut stones, upon which are again placed two horizontal layers of oak timbers, firmly bolted together and with the joints crossed, as shown in fig. 2.

In some very large hammers these horizontal layers are replaced by a foundation formed of oak timbers from 0.250 to 0.350 meter square, carefully framed together,

* The ton used here is the metric ton of 1,000 kilos, or 2,204 lbs.

and joined by wrought-iron wedges, as shown in fig. 6; the height of this foundation varies from 0.600 to 1.200 meters. In some cases, and to avoid the use of the wedges, this timber bed is surrounded by a wall of masonry, as shown in fig. 3.

This timber bed is intended to absorb, in part, by its elasticity the vibrations due to the blow of the hammer upon the anvil, which are transmitted to considerable distances; these distances varying with the nature of the soil.

At Creusot, in the foundations of the 100-ton hammer, the gap between the bed-plate and the masonry walls, in-

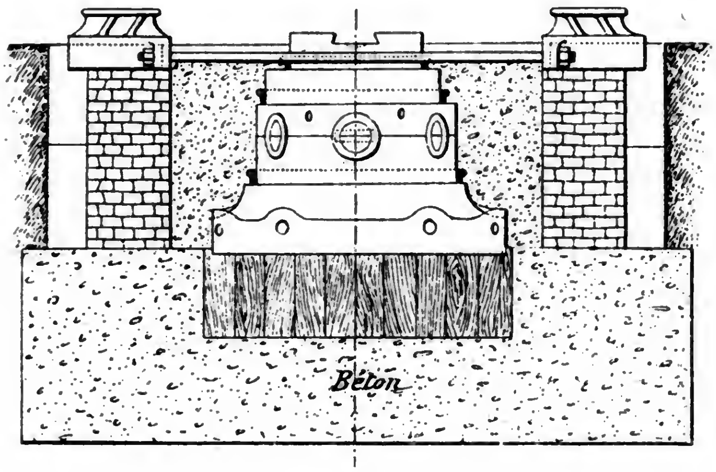


Fig. 3.

stead of being filled in with sand or beton was filled with large oak timbers laid down in rows, in order to lessen the transmission of the shocks from the main bed-plate to the blocks of masonry supporting the independent bed-plates of the frame; this arrangement is shown in fig. 5.

Where independent bed-pates are used to support the frame there are placed below the mass of beton large blocks of cut stone, the spaces between being filled in with rubble masonry; these blocks of stone are intended to receive the bed-plates for the frame. These bed-plates are fixed, as is also the frame, to the masonry, by heavy keyed bolts with wide heads and washers below, so that the bolts can be tightened from above; such bolts are shown in figs. 5 and 6.

CHAPTER IV.

THE BED-PLATES.

We distinguish two classes of these bed-plates or foundation-plates.

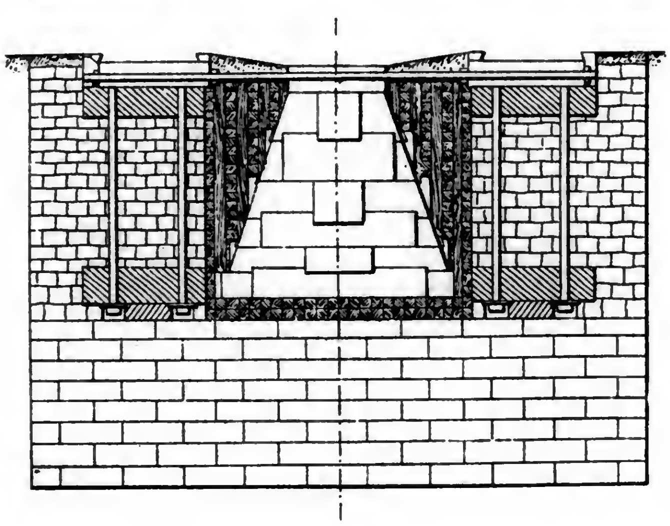


Fig. 5.

1. Bed-plates receiving the uprights directly, as shown in fig. 1.
2. Sockets independent or separate from the main bed-plate, as shown in figs. 2, 3, 4, 5, and 6.

The first type can be used for hammers whose power does not exceed 10 tons. Marrel Brothers, of Rive de Gier, have, however, used this type for all their hammers up to 50 tons.

The second type is usually employed for hammers of 10 tons or over.

The objection to hammers whose uprights rest directly on the bed-plate is that, in spite of the great dimensions and weight of the upright, and whatever method of fastening to the bed-plate may be adopted, they will always after a time work loose, under the influence of repeated heavy

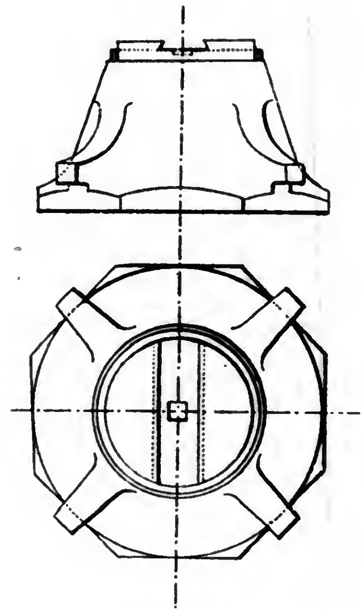


Fig. 4.

blows and continued work. This occurs not only below, but also above, at the junction with the cylinder bed.

Where the independent or separate socket is used, these inconveniences disappear, and a more complete stability is secured. This system also permits a reduction of the section of the uprights, as the reactions produced by the blows of the hammer are very much diminished.

The form of the bed-plates of the first type varies according to the arrangement of the uprights and their size; in all cases the object should be to give the base the greatest size possible, in order to increase the stability.

The form of the sockets of the second type varies ac-

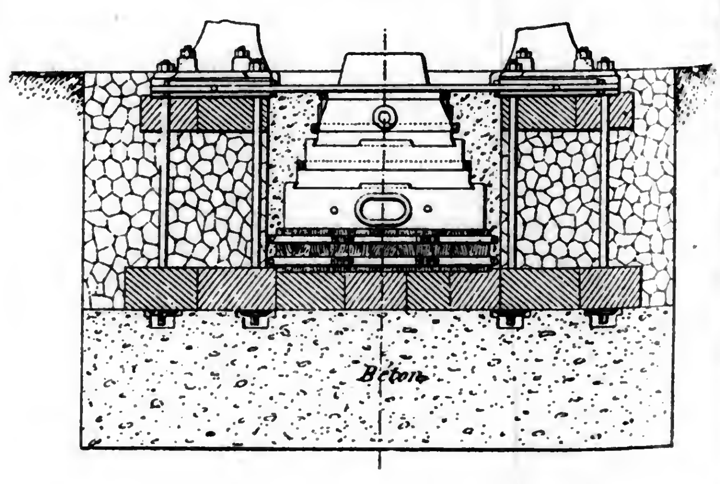


Fig. 6.

cording to the designers; they are given generally the form of a truncated cone or pyramid, with a square or rectangular base; this form is adopted in order to avoid any rotary movement, and to keep the dovetails or wedges

exactly in the axis of the hammer. This is an indispensable condition to make the hammer and anvil correspond properly, that is, to bring the striking surfaces directly opposite each other.

These sockets or foot-pieces may be in one or in several pieces, according to the conditions in which they are placed. If their transportation presents serious difficulties, or if it is desirable to avoid the adjustment of the parts, the bed-plate may be cast in place, and in a single piece. For this purpose cupolas are placed at the site chosen for the hammer, the bed-plate is then moulded and finally cast. The mould is always arranged in such a way as to have the bed-plate reversed, that is, the base uppermost, and two trunnions or journals sufficiently strong to support the plate are placed at a proper height.

As soon as the casting is sufficiently cooled—the time varying according to the size and weight—the sand, etc., are cleared away from the casting, care being taken that the trunnions are supported properly. The bed-plate is then allowed to turn by the action of its own weight—the trunnions having been placed a little above the center of gravity—and all that remains to be done is to lower the plate into its place, after having prepared or dressed off the upper face intended to receive the anvil-block.

It may be noted that a large bed-plate should be left at least one or two months in the sand before stripping it, and that the stripping should be slowly and gradually done. It sometimes happens that bed-plates which have not been subjected to blows or shocks break in two. This is due to the fact that the casting has been stripped and the sand removed too soon, the center not being yet sufficiently cooled; the molecules are then in a state of tension which is broken by the first blow.

The Bietrix Works, at St. Etienne, France, in this way cast two bed-plates, one of which weighed 65 tons, and the other 95 tons.

Marrel Brothers also cast in place the parts of the bed-plates of their 50-ton and 100-ton hammers, in order to avoid the difficult and costly work of moving such heavy pieces.

This plan is also frequently adopted by English engineers. The bed-plate of the great hammer built at Perm (Russia), in 1873, which weighed in all 623 tons, was cast in place, and has now been in use 15 years without giving any trouble.

Quite recently, at the Terni Steel Works in Italy, a bed-plate weighing 1,000 tons was cast in place; the operation succeeded so well that there is every reason to expect that this plate—the largest piece ever cast—is perfectly sound and able to resist all the blows which it is likely to receive.

When the bed-plates are in several parts, each horizontal seat, whose weight is not over 80 or 100 tons, should be preferably in one piece, and each of these seats or plates should be finished on the edges with great care, in order to secure perfect contact of the parts and to make the plates exactly parallel. All these plates are then brought together by means of a series of hoops or bands put on hot, and by clamps which make all displacement impossible, and make the whole a compact block which cannot get out of shape.

All bed-plates should have on the outer edge and at a certain height (as shown in fig. 3) a series of holes, in which can be placed round bars of iron or steel to serve as points of attachment for lifting-jacks or cranes, when it is necessary to move them.

In some cases lugs or arms are made on the casting, which serve the same purpose. An example of this is shown in fig. 4. The first plan is better, however, both because it is safer, and because the plain casting is more easily moulded.

In general, and where there is a good foundation, the ratio between the weight of the active part of the hammer and the weight of the bed-plate should never, in a single-acting hammer, be less than 1 : 6, and the base should be given the largest surface possible, the height being also reduced; under these conditions a bed-plate will act well and will not be apt to get out of level.

This may be verified by the formula:

$$Q = \frac{T}{m + 2}.$$

In this formula Q represents the quantity of work lost during the blow; T the falling force or force of gravity developed during the blow; m is the ratio between the weight of the bed-plate and that of the active part of the hammer.

An inspection of this formula will show that Q will decrease as m increases. Thus, if we assume $m = 6$, we will have:

$$Q = \frac{T}{m + 2} = \frac{T}{8} = 0.125\ T.$$

If we assume again $m = 10$, we have:

$$Q = \frac{T}{m + 2} = \frac{T}{12} = 0.0833\ T.$$

In the case of foundations on light or shifting subsoil, the ratio 1 : m should never be less than 1 : 10, and the base of the bed-plate should have as large a surface as possible.

As noted above, however, where a hammer of any size is placed where the subsoil is light or of a shifting or uncertain nature, it will generally be necessary to drive piles for the foundation to rest on.

(TO BE CONTINUED.)

NOTES ON THE SEWERAGE OF CITIES.

(Translated from paper of M. Daniel E. Mayer, Engineer, in the *Annales des Ponts et Chaussées.*)

(*Continued from page* 209.)

III.—VOLUME OF WATER TO BE DISCHARGED BY SEWERS.

THE principle which we have laid down above, of determining of the size of sewers by their duty, requires us to establish as exactly as possible the quantity of water which they ought to carry.

Waters which sewers must discharge may be divided into two classes.

1. Waste or polluted waters, including the product of water-closets; waters of public service, and water from industrial establishments; that is what we call ordinary duty.

2. Rain water.

Sewers can also, in some cases, receive a third class of water, that of land drainage. In general, however, the street sewer should not be considered as a means of drainage. For stability and economy they should be built as much as possible above the subterranean water-basins; and besides there should be no communication between them, in order to avoid pollution of these subterranean systems. Drainage of low grounds, in cases where it is necessary, should be done by distinct channels, drains built for the purpose. It may, however, happen that a main or collecting sewer may be sufficiently low to receive the flow of such drains. This, although an interesting matter, is, from our point of view, only accessory to the general question of sewers. The danger to health of which we have spoken above, resulting from the fluctuations of the subterranean waters, can be usually avoided if the germs of infection are completely carried off, instead of being allowed to soak into the soil and mix with the water contained in it. As to the lowering and regulation of the subterranean streams, it is more often a matter of special interest to certain property owners than a public necessity. If the other requirements of the system make it necessary to build sewers of such a kind that they can receive the drainage of low spots of ground, so much the better; but we should guard carefully against increasing the expense which falls upon the entire community, in order to drain the cellars of certain buildings which have been placed too low. For these reasons it is not necessary to consider the drainage question to any extent.

The total volume of the waste waters of the public service and of manufactories can usually be easily deter-

mined, especially in those cities where there is a public distribution of water.

In Paris, the public service (the sprinkling of streets; the washing-out of the gutters; the waste of the public fountains, etc.) is of very large volume, corresponding to something over 100 liters of water per inhabitant per day. It must be noted, however, that the washing out of the gutters, which absorbs the larger part of this consumption, should be considered as an extra service, applicable only to Paris, and which will have little or no interest in a city where, by a complete system of sewerage with which all the houses are connected, the refuse water is carried off below ground, and is not allowed to run into the gutters. The public service, reduced to sprinkling of the streets and the waste of public fountains, should not represent in a city more than 10 or 15 per cent. of the amount of the private service.

It may be noted that the street gutters are not washed out either in London, Berlin, or Vienna.

The daily consumption for private use is fully satisfied, as a rule, with less than 100 liters per inhabitant per day.*

It may be accepted, then, as a rule, that in a city where there is not a large consumption of water for manufacturing purposes, the sewers will not have to carry more than 150 liters per inhabitant per day. In Berlin, in Vienna, and even in Paris (if in this last-named city the public service is deducted), the real quantity is considerably below these figures.

If, then, we designate by S the number of hectares served by a sewer, and by N the number of inhabitants per hectare, the ordinary duty of the sewer in cubic meters per 24 hours will be generally well expressed by the formula

$$q = 0.150\ S N.$$

If this whole duty is confined to 12 hours of the day, the following formula will give an approximate value of the average duty per second:

$$Q = 0.00000347\ S N.$$

It may be noted here that the average number of inhabitants per hectare is in Paris, 300, in Berlin, 200, in Vienna, 135, while in several smaller French cities it varies from 133 to 50.

The existence of large manufacturing establishments consuming much water may render this estimate much too low; a factory having steam-boilers of 500 H. P. will, with condensation, take alone a quantity of water greater than the entire consumption of a city of 20,000 people. It is generally the case, however, that these large establishments are found in valleys or in the lower parts of towns, and the waste water when comparatively pure, like water of condensation, can be conducted directly into the river.

In any case the ordinary duty can be easily calculated, and although it will vary from one day to another, and from one moment to another of the day, it will nevertheless present in total a certain regular character. All the water discharged does not, it is true, reach the sewers; a portion is lost from various causes, but it would be much more difficult than useful to take account of these losses in our estimates.

It is not the same with rain water.

If we average through the year the total rainfall received in the basin by the sewers, we will easily obtain in this climate a figure lower than that which we have indicated, for the ordinary duty of the sewers. But in reality this average is not of practical interest. It would be an advantage toward working out the problem if we could divide the total annual rainfall by the actual time during which rain fell. At Paris, for example, where the average total annual rainfall is about 0.006 meters, observation has shown that the actual time during which rain fell averages 0.052 of the total time; from this we may calculate the average amount of rain per hectare per second as follows in cubic meters:

$$\frac{6.000}{365 \times 86{,}400 \times 0.052} = 0.00366.$$

Of this, however, only a part reaches the sewers, on account of loss by infiltration and by evaporation. In larger cities, where the loss from these causes is relatively small, because the greater part of the surface is either built on or paved, it is probable that two-thirds of the water which falls reaches the sewer, and if we accept this as the basis of calculation, we find that the duty of a sewer in an average rain would be double its ordinary service. It must be remembered that we are here speaking of an average rain. The duty per second due to this rain will be generally less than the formula above indicates, because it is necessary to take account of the time which rain occupies in reaching the sewer. It is seldom that we are called upon to carry off more than one-sixth of the quantity of rain which falls during a given time on the area served.

In smaller cities it is probable that a different report would be made, but it must be remarked that the terms upon which the report depends would vary in the same direction. Where the density of population is less, the proportion of gardens, vacant and cultivated land is greater, and it would thence result that a much larger proportion of rain would be lost before reaching the sewers, while on the other hand the ordinary duty per hectare also diminishes in proportion to the density of the population. It is therefore extremely probable that the proportion given for Paris can approximately apply to other cities.

However this may be, this calculation will not give us the maximum capacity which the sewers should have to carry off rain water. There are violent rains and showers in which in a few minutes there may be 40 or 50 times as much water fall as we have calculated above. Different observers have estimated the greatest known rainfall, in this climate, at from 0.125 to 0.160 cubic meters per hectare per second.

It would, however, be entirely unnecessary to insist that the sewers should have sufficient capacity to carry off so great a rainfall as this. In the first place, there are the losses above referred to, by infiltration and by evaporation. Further, the total capacity and extent of the system of sewers is seldom called upon to receive the volume of water falling in these exceptional rains, which if very violent are generally very short. The sewers will have a certain time to fill and discharge themselves, and the chances are that the intensity of the shower will have passed before any serious obstruction will take place.

It is to be desired that rain water should be promptly carried off, but it is admissible to take for the discharge a somewhat longer time than the duration of the rain, and the resulting inconvenience will be much less serious than that resulting if we give the system too great a capacity, merely to provide for a few exceptional cases.

Taking into consideration these different points of the question, Belgrand estimated that at Paris the sewers ought to provide for a volume of rain water equal to one-third of the maximum fall—that is, 0.04167 cubic meters per hectare per second. The figure adopted for Berlin was only one-half of this.

Without entering into a profound discussion of this problem, which is really a very complicated one, and which has caused the flow of oceans of ink, we should advise the adoption, in a climate like that of Paris, of the figure of Belgrand given above, deducting, however, in the calculation of the amount of surface, gardens and other cultivated or unoccupied land.

Thus calculated, the maximum duty of a sewer for rain water is about 30 times as great as the ordinary discharge.

This result will without doubt differ in different cities, but it will serve for a general approximation.

Some English engineers have proposed to adopt for certain cities two separate systems, one for rain water and one for the ordinary discharge, holding that the same system cannot be made to serve two discharges, the conditions of which are so different. We do not believe, however, that it would be well for cities to adopt two separate systems; partly because two systems would be very much more costly than one, and partly because the rain water will sometimes serve a useful purpose in assisting the discharge of waste water and washing out the sewers. There is still another reason opposed to this plan, and that is, that in times of only average rainfall, or in dry seasons, the water which falls is heavily charged with organic matters, taken up in passing through the air, or in running

* M. Mayer's estimate (22 gallons) per inhabitant per day is lower than would be generally accepted in this country.—EDITOR.

through the gutters, and that considerations of public health would not allow the discharge of such waters into rivers. In reality they would be almost as dangerous and would pollute the natural water almost as much as the ordinary discharge of sewers.

It may be the case, however, in small towns, where the surface of the ground is such as to give sufficient slope to permit rain water to flow freely, and where an occasional overflow at a street-crossing would not be a serious evil, it might be possible for reasons of economy to suppress entirely the discharge of rain water, and thus to reduce very much the necessary dimensions of the sewers. It is also possible to imagine some arrangement by which in wet weather a portion of the rain water may drain into the sewers at certain points, and thus be used to flush or clean them out.

To return to the more general case of a system which is to receive at the same time both discharges, we may remark here that if the highest figures given above be accepted, the dimensions of sewers required to receive the maximum volume of rain water would tend to become enormous, where they have to serve any large extent of surface. In Paris, for example, where the total surface served is about 8,000 hectares, the main or collecting sewers should be able to discharge 320 cubic meters per second; that is, seven or eight times more than the flow of the Seine at low water.

The construction of such gigantic works would be impossible, but fortunately their size can be very much reduced.

We must, in fact, consider that when the intensity of a storm exceeds the average rainfall, the foul waters are mixed or diluted in an enormous quantity of pure water, and that at the same time the volume of water in the river is very much larger than usual; we thus arrive at the conclusion that in very heavy rains it is permissible to discharge the surplus from the sewers into the river. This is what is done in Paris, Berlin, and Vienna, and in many other important cities.

We should have, therefore, at certain points conveniently chosen, and especially in the main sewers, arrangements by which the water can be diverted into overflow passages connecting directly with the river. Where a new and properly arranged system is introduced, the old sewers can sometimes be utilized for these overflows.

Thanks to these considerations, the data which we have indicated above, for calculating the maximum amount of rain water to be discharged, must be accepted only in that portion of the system which is highest and most distant from the main discharge. In the lower portions of a town furnished with overflows the capacity of the works above the level of the main sewer may be determined by the ordinary discharge, increased by the amount of an average rain, which, as we have already shown, will give a total of about three times that of the ordinary discharge.

It is hardly necessary here to recall the fact that in estimating a system of this kind, we must always consider the future, in which, by the increase of population or by construction of new buildings or factories, the volume of water to be handled in the sewers may be considerably increased. The engineer must study the future, but he must, on the other hand, remember that the money saved by present economy may constitute a fund on which his successors may be able to draw to better advantage, because with fuller knowledge of what is needed.

(TO BE CONTINUED.)

The British War-Ship "Nile."

A NEW war-ship named the *Nile* was launched at the Pembroke Dock-yard on March 27. The following description of the vessel is from the London *Times*:

Before proceeding to describe what kind of ship the country will in course of time obtain in the *Nile* for the million or so of money which she will eventually cost, it will be best, in order to provide against mistakes, to say what she is not. Though she divides with the *Trafalgar* the honor of being the heaviest armor-clad in the service, she is exceeded in length by the *Achilles* and in beam by the *Inflexible*. She is not the quickest armor-clad, neither does she carry the largest ordnance afloat. Though the number, nature, and relative positions of her heavy guns are the same as in the *Admiral*, she differs from that class in carrying them in rotating turrets instead of in fixed barbettes. But while the turret principle has thus been re-established, the *Nile* varies from the *Victoria*—the latest embodiment of the system—in having double the number of turrets, and from the *Inflexible* and her successors, of the *Edinburgh* and *Ajax* classes, in the abandonment of the *en échelon* arrangement, as they are built forward and aft on the middle line of the ship, whereby direct fire ahead and astern is reduced by one-half. The *Nile* may be said to resemble the *Dreadnought*, upon which she was evidently modeled; but she has, among other advantages over her prototype, the important one of possessing a powerful auxiliary broadside battery high up between the turrets. The *Nile* has greater length, thickness, and depth of water-belt than the *Admiral* class, and though she is not like the early armor-clads, protected throughout her length by vertical armor, her invulnerability against the penetration of the heaviest guns afloat is immensely greater. Her engines will be of exactly the same horse-power as those of the *Victoria*, but notwithstanding the fact that she exceeds the Tyne-built ship in displacement by considerably over a thousand tons, yet in consequence of her superior lines and length she is expected to realize the same speed.

In short, it will be perceived that, although it has been declared impossible to design a perfect ship combining in herself the several excellencies of different types, it has been the evident desire of the designers of the *Nile* to combine as many good points in her as possible by a series of compromises. The *Nile* will possess great speed and offensive powers combined with efficient protection for all vital parts.

In none of these respects will she be likely to become antiquated in her armament and dangerous as regards her defense soon after being launched, provided only that the paramount factors of stability and speed could be kept in view. An ordinary cylindrical boiler would probably furnish the best design for a ship of war, since, besides securing a *maximum* degree of buoyancy, its contours would cause shot to deflect wherever it was struck. In the *Nile* curves of beauty, because they also happen to be of practical utility, have certainly not been lost sight of. Glanced at in midship section, her sides taper gracefully downward; while, if examined in plan, she presents the appearance of an elongated ellipse, having ogival ends like the head of a Palliser projectile. Forward her armored deck curves down from the lower citadel to the ram, while at the rear it is bent in the same way to support the stern post. The turrets are, of course, circular, but, for the purposes of protection against raking, the bases are inclosed within an upper citadel having rounded athwart bulkheads. The turrets themselves are surmounted by turtle covers, while the intervening box battery is octagonal in shape and consequently is as near an approach to a circle as was practicable. In length the *Nile* measures 345 ft. between perpendiculars and 73 ft. in beam. Her load draft will be 27 ft. forward and 28 ft. aft. When fully equipped for sea her displacement is 12,000 tons and her engines are contracted to develop the same number of horses under forced draft. The hull is built wholly of steel, the flat plates having an outer thickness of $\frac{3}{4}$ in. and an inner thickness of $\frac{5}{8}$ in., while the bottom plates are $\frac{9}{16}$ in.

These details, however, will afford only an indifferent idea of the structural strength, because the portions of the hull carrying weight and exposed to strains and blows are specially thickened and strengthened, more particularly in wake of the turrets and vertical armor. Thus it is officially stated that the side of the hull behind the heavy plating consists of two thicknesses of skin, the outer of 60 lbs. and the inner of 30 lbs. a square foot, riveted to plate and angle frames 2 ft. deep and 2 ft. apart. Inside of these, again, frame plating of 20 lbs. a square foot is worked, while the belt and citadel armor bolts are hove up between them on the inner end of a cast-steel sleeve 12 in. long. Within these frames and behind the belt armor is a second

system of lightened plate frames 3 ft. deep, spaced 4 ft. apart, upon the inside of which the outer bulkhead of the coal bunkers is riveted. Besides the solidity of the structural arrangements, the under-water portions are safeguarded by a unique subdivision double bottom, which is 3½ ft. in height and contain 40 water-tight compartments. There are also 13 before the double bottom and 18 abaft and 49 in the hold, including eight divisions in the coal bunkers, making altogether a total of 120 water-tight compartments below the protective deck. In addition to the above, however, must be added 14 similar compartments on the protective deck itself in wake of the water-line, and as these would be filled with stores, it is contended that they would give considerable buoyancy to the relatively limited unarmored ends of the ship when riddled. As a matter of fact, it is asserted that, should the unprotected forward end be entirely filled with water, the resulting sinkage would only amount to 3½ in. as compared with the 15 in. of additional sinkage of the *Admiral* class in similar circumstances. But should these various compartments be flooded, it is important to notice that exceptional means have been take to free them. This may be done either by hand or steam-power, or by both in combination, Downton's pumps being used for hand and the circulating pumps as well as the bilge-pump donkey-engines for steam-power. Each of the two main circulating pumps will be powerful enough to discharge 1,000 tons of water from the bilge in every hour in case of leak, while the two pumping engines and the couple of auxiliary engines can also be called into requisition for the same purpose.

When it is stated that the *Camperdown* would carry four 67-ton guns into action upon a displacement of 10,000 tons, and that the *Nile* would do no more with a displacement of 12,000 tons, it will be readily surmised that the latter must possess commensurate advantages in the way of speed, armored stability, and protection. Her great superiority as regards speed is universally acknowledged. Her total weight of armor, exclusive of glacis plates and protective decks (which may be roughly said to represent an additional 1,000 tons), is not less than 4,230 tons. The disposition of this enormous mass of compound armor is the distinctive feature of the hull. In the first place, the *Nile* is fitted with a belt thicker, longer, and extending both higher and lower than that of the *Admiral's*. It has a length of 230 ft. and a breadth of 8 ft. 6 in., and forms, with the boundary bulkheads, the lower citadel. The line is thus protected for 5 ft. 6 in. below and 3 ft. above the water. The plating varies in thickness from 20 in. to 14 in., tapering at the lower edge from 8 in. to 6 in., while the bulkheads are armored with 16-in. and 14-in. plating forward and aft, respectively, tapering downward to 7 in. It will thus be seen that each of the ends is denuded of vertical armor for the space of 58 ft. They are, however, protected by a 3-in. sloping steel deck in continuation of the belt. Above the lower or belt citadel is the citadel proper, 141 ft. long at the sides of the ship, but having an extreme length from the centers of the curved bulkheads of 193 ft. The plating varies from 18 in. to 16 in., while the thickness of the bulkheads which protect the bases of the turrets from raking has been perilously reduced to 8-in. The main-deck between the ends of the citadel and the end of the armored belt is covered with two thicknesses of steel plating, similar deck-arming forming the upper deck over the citadel. These figures will afford an idea of the defensive capacity of the ship, but in reality, in consequence of the peculiar arrangement of the framework and backing, the protecting barricades are of much greater solidity.

It also remains to be stated that, owing to the great length of the main citadel, it has been deemed expedient to subdivide it into three compartments by means of thin steel bulkheads, as a defense against splinters. The turrets are built at each end of the citadel. Within the limits of the armored belt, and circumferentially to the parabolas of the boundary bulkheads, they are armored to the thickness of 18 in., and will each mount a brace of 67-ton breechloaders. Both guns and turrets will be worked by hydraulic power. Superimposed upon the citadel is a box-battery pierced for six of the new 36 broadside quick-firing guns. In this respect the *Nile* differs from the *Trafalgar*, which is to carry eight 5-in. breechloaders. The ship will also have 18 machine guns and eight tubes for discharging torpedoes. As the side of the battery is only built of 1-in. plating, the guns' crews will be exposed to the fire of the smallest guns. The central portion of the *Nile* is a three-story arrangement, and as the turrets are not less than 120 ft. apart, it is, perhaps, to be regretted that some portion of the intervening armored side, which rises to the height of 11 ft. above the water, was not made available for a few thoroughly protected guns. In the *Nile*, as in the *Trafalgar*, the magazine and shell rooms are located in the lower part of a water-tight tunnel, which passes between the two sets of engines and boilers, and affords a means of communication between the ends of the ship.

The *Nile* will be propelled by two sets of triple-expansion vertical engines by Messrs. Maudslay & Co., which, with an indicated horse-power of 12,000, are expected to drive the ship at the rate of 16½ knots. The radius of steaming distance is officially stated to be 1,050 nautical miles at full speed and 5,500 at 10 knots. But all calculations of this sort are vitiated by the fact that the coal stores are not exclusively used for propelling purposes. The ship's galleys and fires will consume nearly a ton a day, while the fuel used in condensing amounts to about five tons a day. The *Nile* will also be original in the disposition of her funnels, since instead of having one behind the other, as has hitherto been universally the case, they will be abreast.

It only remains to be added that the ship will be fought from the pilot-tower on the spar-deck and from two conning-towers at the side, and that her steering will be controlled from five stations by steam-power and also by hand gear from below the protected deck. As the ship is not to be docked at Pembroke, her propellers were fixed in position before launching, two blades being secured on each shaft.

The *Nile* was built by Mr. Millard, Assistant Constructor, under the direction and superintendence of Mr. George Malpas, Constructor, and Mr. J. C. Froyne, Chief Constructor, from the designs of Messrs. Barnes and Morgan, of the Admiralty Constructive Department.

Torpedo-Boat for the Chinese Navy.

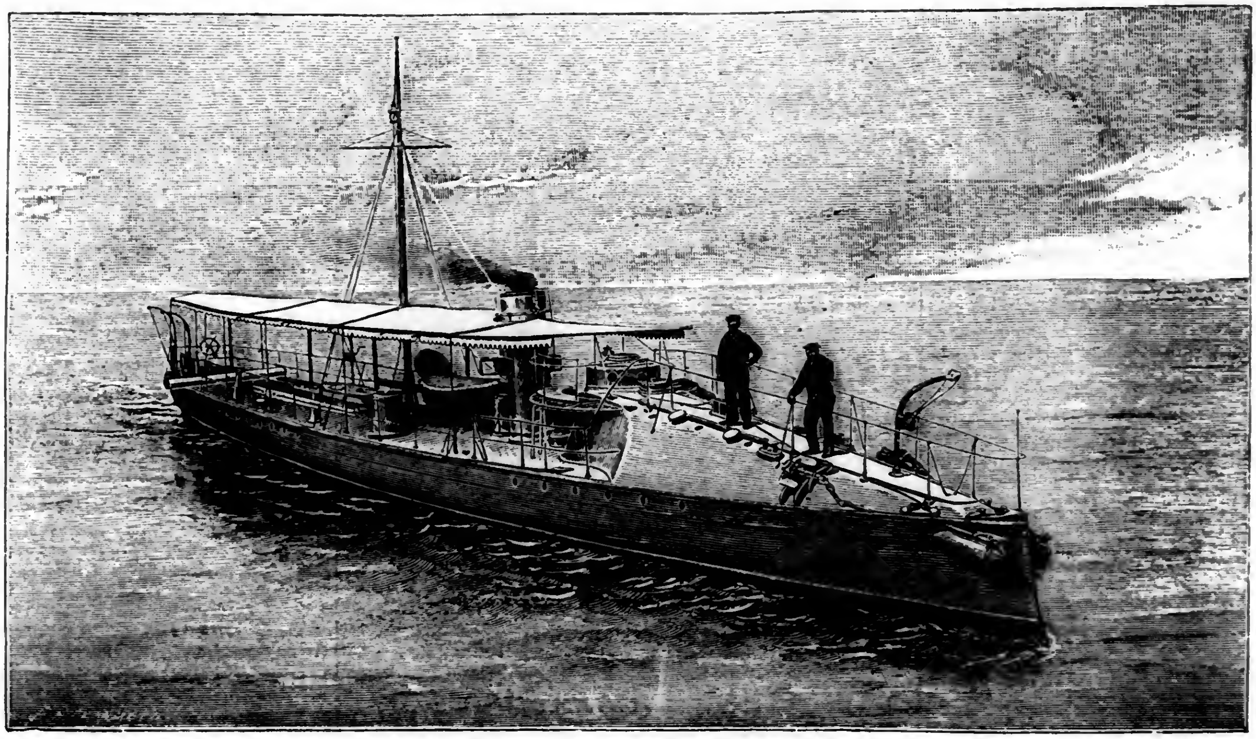
(From the London *Engineer*.)

THE torpedo-boat illustrated herewith represents probably the most useful type and size of such craft suitable for coast defense which has been hitherto constructed, it being capable of safely withstanding any weather and carrying a powerful armament. Smaller dimensions would not secure the needful seaworthiness and accommodation to make it suitable for remaining at sea for a lengthened period, and larger dimensions would unnecessarily augment the cost and increase the area exposed to an enemy's fire. This vessel was built by Messrs. Yarrow & Co., for Messrs. Birch & Co., in accordance with a contract between the latter firm and the Chinese Government. The opinion of many competent naval authorities at the present time seems to be that the limit in size for torpedo-boats properly so called, is that of the vessel we illustrate, and in support of this it may be mentioned that all the 50 torpedo-boats lately built for the British Government were of the same dimensions, although in speed very far inferior, excepting only No. 79, which was the first of this type constructed.

Recent advices have been received that this little vessel has most successfully made the voyage out to China with the rest of the fleet, notwithstanding that she encountered, at times, the very worst possible weather. We must congratulate the builders on having scored another success by combining in one vessel so great a speed with ample strength to withstand the strains to which she was subjected. Notwithstanding the high speed obtained, she is a comparatively full-lined boat, and can consequently carry a proportionately large supply of coal, stores, and armament, and possesses the most necessary quality of stability in a high degree. She is 128 ft. long by 13 ft.

beam, and her displacement on the official trial was a trifle over 70 tons. She is divided by water-tight bulkheads into 10 compartments; each compartment, except those at the extreme ends, has its own hand-pump and a steam ejector varying in power of delivery from 40 to 80 tons of water per hour. There is one large boiler, of the locomotive type, with a copper fire-box and brass tubes, constructed in accordance with the builder's most recent practice, and this is protected by coal bunkers on either side and also at the end.

The engines are on the triple-expansion principle, with three cranks and link motions, the air and feed-pumps being worked by the main engines in such a manner as to make them very accessible for examination. There is a large surface condenser, and provision is made for very perfect condensation by securing an exceptionally large amount of circulating water. Forced draft is, of course, adopted, and there is the usual fan and engine for the purpose. The crew and petty officers have their quarters forward under a roomy turtle-deck, and abaft this, but forward of the boiler, is the cooking compartment and galley. In the after part of the boat are the quarters for the officers, consisting of two private sleeping cabins, a large, handsomely fitted saloon, and a pantry; also in a separate compartment a lavatory and other needful fittings. Quite aft there are store-rooms. Steam steering gear is provided in the conning-tower, which forms the termination of the turtle-deck forward of the funnel. The boat can also be steered from aft, as there is a separate wheel and gear for that purpose, fitted specially for the voyage out. The armament is a heavy one, consisting of a pair of torpedo tubes built into the bows underneath the turtle-deck for direct ahead fire, and a single torpedo tube revolving on a turn-table aft, which will discharge on either side and at any required angle. There are three rapid-firing guns, one of which is mounted on the top of the steering or conning-tower, and besides these there are four Gatling six-barreled guns on stands on the after part of the deck. The boat is lighted by electricity throughout; incandescent lamps being used, and a powerful search-light on a traversing carriage is mounted amidships. The dynamo to supply the various lamps is driven by a Parson's high-speed engine, and is placed in the engine-room, where also is the air compressor for charging the torpedoes. On the official trial in the Lower Hope below Gravesend, under the superintendence of Admiral Lang of the Chinese Navy, a mean speed was obtained during six runs, three with and three against tide, of 23.882 knots, and on a subsequent two hours' trial 22.94 knots. She had her armament on board and was in average sea-going trim. After the speed trials had been made, the maneuvering powers were tested, circles being made to port and starboard having diameters of about twice the length of the vessel; the steering qualities equaling those of the No. 79 of the British Navy, which was lately built on a similar model by the same firm.



TORPEDO BOAT FOR THE CHINESE NAVY.

Built by Yarrow & Co., Poplar, England.

UNITED STATES NAVAL PROGRESS.

THE naval event of the past month was the launch of the gunboat *Yorktown* and the dynamite cruiser *Vesuvius*, which took place April 28 at the yard of Cramp & Sons, in Philadelphia, in the presence of the Secretary of the Navy and many distinguished guests. The dynamite cruiser was described and illustrated in Captain Zalinski's paper published in our columns last month, but some further account is given below, with a description of the gunboat.

THE DYNAMITE CRUISER.

This cruiser has a displacement of 725 tons; length between perpendiculars, 246 ft.; beam, 26 ft.; mean draft, 9 ft. She is designed for a speed of 20 knots, her engines being of the twin-screw triple-expansion type, developing 3,200 H. P. The cylinders are $21\frac{1}{2}$, 31, and 34 in. in diameter. There are four boilers, $19\frac{1}{2}$ ft. long and 9 ft. diameter, placed in independent fire-rooms. Forward of the fire-room are the quarters for the crew, while the captain's saloon and the ward-room, with state-rooms for four officers, are in the after end of the vessel. She has no spars or sails, and the only projections above the upper deck are the conning-tower and a small superstructure amidships. The conning-tower is built just abaft the guns, and is made of 1-in. steel plates.

The dynamite guns are three in number, placed side by side at an inclination of 16°, projecting a few feet above the deck, near the bow, and extending down nearly to the keel. The lower part of the guns and the crew engaged in loading them are protected by a light water-tight protection deck. The guns are fixed in position—built into the ship—and will be pointed by the helm, the steam-steering engine and the two screws furnishing the power for quick turning. The guns are of 15-in. caliber, throwing shells containing 600 lbs. of explosive gelatine and dynamite; their construction and the method of operating them were very fully explained in Captain Zalinski's paper.

THE GUNBOAT "YORKTOWN."

Gunboat No. 1, named the *Yorktown*, is a twin-screw, coal-protected steel cruiser, with poop and forecastle decks and an open gun deck between. The principal dimensions are: Length between perpendiculars, 226 ft.; draft, 13 ft. forward and 15 ft. aft; breadth of beam, 36 ft.; displacement, 1,703 tons. The rig is that of a three-masted schooner, spreading 6,300 square feet of canvas—sufficient sail power for cruising purposes in times of peace and to insure economy of coal at all times. The two main engines are placed in separate water-tight compartments, and are of the latest triple-expansion type, designed to develop 2,200 H. P. with natural draft and 3,300 H. P. with forced draft, which should give a maximum speed of over 17 knots. The cylinders are 22, 31, and 50 in. in diameter, respectively, with 30-in. stroke, and are fitted with piston-valves. The three-bladed screws are 10½ ft. in diameter. There are four cylindrical horizontal boilers 9 ft. 6 in. in diameter and 17 ft. 6 in. long, having a grate surface of 220 square feet.

The maximum coal capacity is 400 tons, the coal-bunkers being so placed as to protect the boilers and machinery against shot and shell. At a speed of 16 knots the *Yorktown*, starting with her coal-bunkers full, could steam 6½ days and cover a distance of 2,800 miles. At 12 knots speed she can steam 20 days and a distance of 5,750 miles, while at 8 knots she can keep the sea for 62 days and steam 12,000 miles. It will be seen from this that the *Yorktown* will prove a most efficient cruiser, and with her sail power as auxiliary she will be able to maintain herself at sea for months without being compelled to run into port for coal.

In addition to the coal protection for the vitals of the ship, there is a curved water-tight steel deck ⅜ in. thick extending from stem to stern, its crown being at the level of the water-line, while its sides slope to 3 ft. below the water-line, thus forming a turtle-back which gives structural strength as well as security from water which might enter through shot holes above it. At the bow and stern this deck curves down to support the ram and to protect the steering gear. Below this protection deck, or turtle-back, transverse bulkheads divide the under-water body of the ship into 12 main water-tight compartments, while above this deck are several additional compartments furnished with water-tight doors to be closed in battle. The ship will be well lighted throughout with electric lights, there being two sets of dynamos. She will also have two powerful search lights, each of 25,000 candle-power, for use at night.

The armament of the *Yorktown* is very powerful for a ship of her tonnage. The main battery consists of six new high-powered steel breech-loading rifles, caliber 6 in., firing a shot weighing 100 lbs., with a powder charge of 50 lbs. Two of these guns will be mounted forward on the forecastle deck, firing directly ahead and on each side; two aft on the poop deck, firing directly astern and on each quarter, and one on each side of the ship, in the waist, on the spar deck, firing through a large arc, as they are mounted in projecting sponsons. All these guns are furnished with segmental steel shields 3 in. thick, which will afford protection for the guns' crews. The bow and stern guns are 18 ft. and the two waist guns 10 ft. above the water-line. The secondary battery will comprise eight rapid-fire guns and revolving cannon. The torpedo outfit is complete and formidable. There is one fixed tube in the bow to fire directly ahead, one in the stern to fire directly astern, and three training or movable tubes on each side which can be fired within a considerable arc. There is also a complete outfit of boat and spar torpedoes.

The conning-tower of steel 2 in. thick is placed forward on the forecastle deck. It is oval in shape to deflect striking shot, and is furnished with steam-steering wheel, telegraphs, and speaking-tubes. The captain, with a helmsman, will be stationed in this conning-tower to maneuver his ship in battle, to control the firing of guns and torpedoes, and to seize the opportunity for ramming.

The 6-in. guns on board the *Yorktown* will pierce 8 in. of steel-faced armor, or 10 in. of wrought iron, at a distance of 1,000 yards. The machine guns are of the Hotchkiss type, and are also powerful, firing shells weighing 1, 3, and 6 lbs., which will pierce from 1 to 4 in. of armor at close quarters. It will be seen, therefore, that the *Yorktown* could fight the less formidable class of iron-clads, while her light draft of water will enable her to run into comparatively shoal water, and thus escape or choose her distance from an enemy.

THE BATTLE-SHIP "TEXAS."

The accompanying illustrations show the general design of the armored battle-ship *Texas*, which is to be built at the Norfolk Navy Yard. Fig. 1 is a side-view, fig. 2 a plan of the main deck, and fig. 3 a plan of the upper deck. These engravings accompanied a paper read before the British Institute of Naval Architects by Mr. W. John, the designer of the vessel.

The dimensions of the new ship are as follows:

	Ft.	In.
Length between perpendiculars	290	0
Breadth (extreme)	64	1
Depth (moulded to upper deck)	39	8
Mean draft of water	22	6
Displacement at 22 ft. 6 in. draft, when fully equipped and with 500 tons of coal on board, 6,300 tons.		

The vessel is to be built on the cellular double-bottom principle. This double-bottom extends under the engines, boilers, and magazines for a length of 158 ft., and is divided both longitudinally and transversely into numerous water-tight compartments fitted for water ballast. Forward and aft a continuation of the double-bottom is formed by the flats of the provision and store-rooms, the extreme ends of the vessel being arranged as trimming tanks. There is a protective deck 3 in. thick extending over the top of the armor belt, and then sloping down forward and aft at the forward end to the point of the ram 10 ft. below the water, and at the after end sufficiently down to protect the steering gear. Below this protective deck there are wing compartments arranged so as to lessen the extent of possible damage of ram or torpedo attacks. The hull of the vessel is to be built of mild steel throughout. Above the top of the belt and the protective deck there are two continuous decks, and the turrets, with the 12-in. guns, are above the upper of these, as seen in the profile. These bulkheads are of 6-in. steel-faced armor. In end-on firing they have, of course, the additional protection of the protective sloping deck, and are, therefore, partly sheltered; and in broadside fighting they must necessarily, from their position, be struck at an oblique angle, if at all. The armor belt is backed up with 6-in. teak, two thicknesses of 25 lbs. plating, rigid framing, and girders. Between the protective deck and the one next above, which we may call the main deck, there is no armor, except round the communications for working and fighting the ship, but the space is divided into water-tight compartments, forming additional coal-bunkers, store-rooms, accommodation for crew, etc. These additional coal-bunkers are further subdivided by water-tight girders longitudinally at a height of 5 ft. above the water-line, and coffer-dams are fitted round the engine and boiler hatches. The main deck carries an armored redoubt, surrounding the lower part of the turrets, and the hydraulic machinery for moving and loading the guns. The redoubt and turrets are of 12-in. steel-faced armor, with 6-in. teak backing, well supported, and the top plating, which forms part of the upper or weather deck, is 1 in. thick. The main battery consists of two 12-in. guns in the turrets just men-

tioned, and six 6-in. guns protected by shields. The turrets are placed *en échelon*, so as to permit of a fore-and-aft fire. Each 12-in. gun has a complete broadside fire on one side, and has a train on the opposite side of 40° for the forward gun and 70° for the after gun. One 6-in. gun is placed forward and one aft on the same level as the 12-in. guns, having each a train of 120°. The remaining four 6-in. guns are mounted in sponsons of the main deck, two having a train from directly forward to 25° abaft the beam, and two from directly aft to 25° forward the beam.

On the main deck the secondary battery consists of four 6-pounder Hotchkiss rapid-firing guns; four 3 pounders, and four 47-mm. Hotchkiss revolving cannon, protected by 1½-in. steel plating. Two Gatlings and two 37-mm. guns are placed on the bridge deck, and two 1-pounder Hotchkiss guns are placed on the flying bridge. Two

The space between the upper and main decks not appropriated by the redoubt and the secondary battery is taken up by the quarters of the officers and crew, which are well lighted and ventilated. Access to the redoubt and turrets is obtained from the protective deck. Steam and hand-steering gear is fitted below the protective deck, and steering connections are made with them from the conning-tower, after wheel-house, and flying bridge. The communications from the conning-tower for navigating the vessel are protected by an armored tube 3 in. thick.

The ship will have twin screws, driven by two triple-expansion engines placed in separate water-tight compartments. The engines will have cylinders 36, 51, and 78 in. diameter, with 39-in. stroke. Steam will be supplied by four double-ended boilers 14 ft. diameter and 17 ft. long. The working pressure will be 150 lbs., and it it is expected

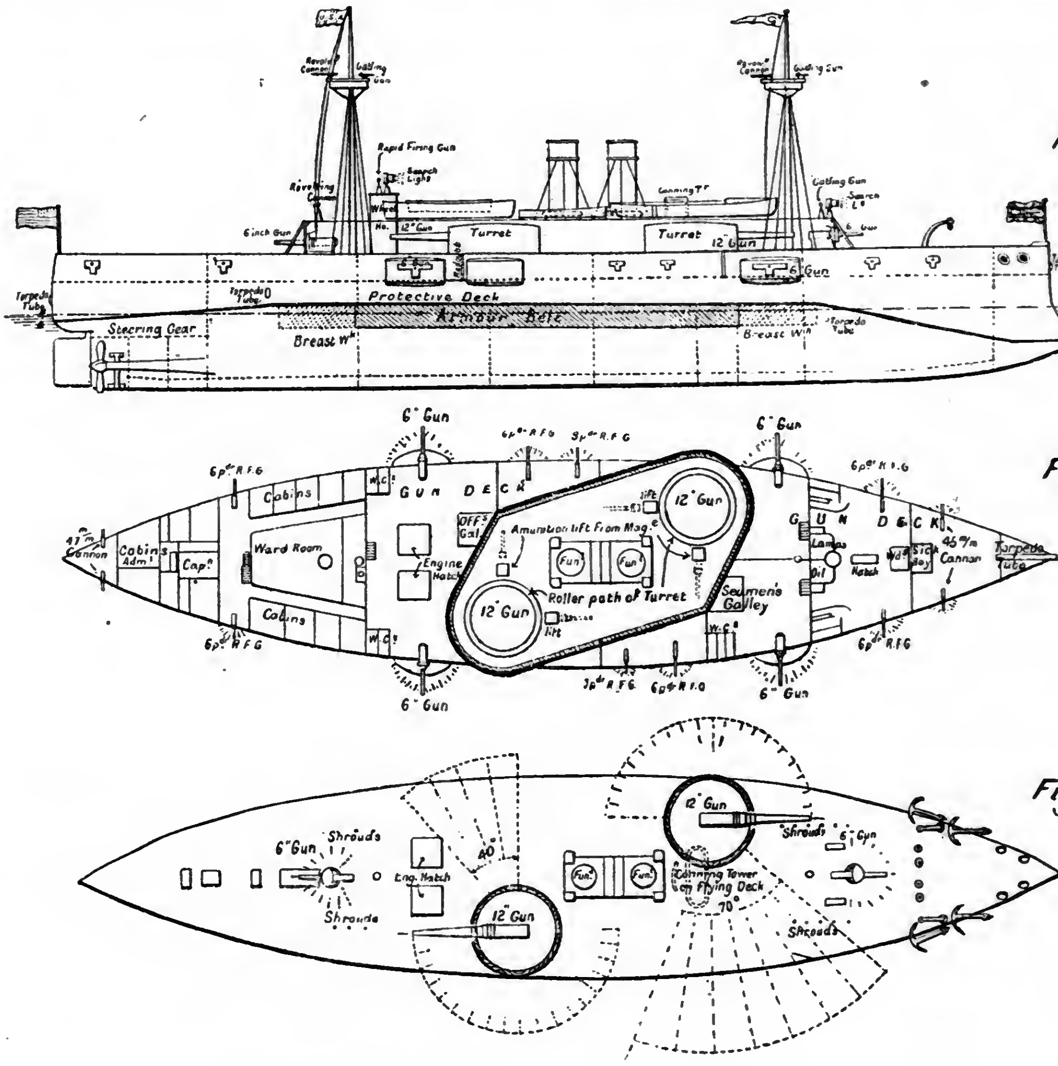


Fig. 1.

Fig. 2

Fig. 3.

ARMORED BATTLE SHIP "TEXAS," UNITED STATES NAVY.

Gatlings with two 37-mm. revolving cannon are fought in the military mast tops to repel boarders and torpedo-boat attacks. Two 37-mm. guns are further fitted in the steam cutters. The magazines for the main battery are placed in the center of the vessel below the protective deck. The ammunition for the secondary battery is stowed in magazines placed forward and aft, the ammunition being passed up to the main deck through an armored tube 3 in. thick. Torpedoes can be projected through six tubes—one through the bow, one through the stern, two through the side aft above water, and two through the side forward below water. Air compressors are to be fitted forward and aft, and stowage room is provided for 14 torpedoes. Stowage room is also arranged for submarine mines.

The ship will be provided with four large electric search lights, besides two smaller ones for the boats.

that under forced draft, with an air pressure of 2 in. of water, they will supply steam enough to enable the engines to develop 8,600 H. P.

At the normal draft of 22 ft. 6 in. the coal supply will be 500 tons. The endurance--that is, the distance the ship can steam at various speeds, with this supply and with the fuller load of 850 tons of coal, which can be carried, is as follows:

Speed.	On 500 tons.	On 850 tons.
17 knots per hour	1,110 knots.	2,180 knots.
15 " "	2,050 "	3,900 "
12 " "	3,170 "	6,000 "

The quarters for officers and crew will be of ample size and well ventilated. Proper ventilation for the magazines will also be provided.

THE NAVAL RESERVE.

The Secretary of the Navy has presented to the Naval Committee of the House of Representatives an argument in favor of some action as to the establishment of a naval reserve. So many other matters are pressing upon the attention of Congress just now, that the probabilities are that nothing will be done on this question at the present session.

THE SUBMARINE TORPEDO-BOAT.

The bids for the submarine torpedo-boat were opened at the Navy Department in Washington, May 3. They were two in number: one from William Cramp & Sons, of Philadelphia, for a submarine boat of the same type as the *Nautilus*, designed by Mr. Holland, of New York, and Captain E. L. Zalinski. This boat, according to the plans submitted, is to be 88 ft. long, and the bid was for $135,000. The second bid was also from William Cramp & Sons, who offered to build a submarine boat of the *Nordenfelt* type, 120 ft. long. This vessel is to include all the latest improvements made by the inventor, and is to be a duplicate of the *Nordenfelt No.* 4, recently built in England. An engraving of this boat was published in the RAILROAD AND ENGINEERING JOURNAL for May, page 210. The bid was for $135,000.

The bids were taken under consideration, and were referred to a board of officers, upon whose report the award will be announced.

BIDS FOR STEEL.

Proposals for the steel for the armored cruiser *Maine* will be received at the Navy Department in Washington until noon of June 4, the formal call for bids having been issued on May 4.

THE MONITOR CLASS.

Under the appropriation made some time ago, arrangements are being made for the alteration and completion of the five double-turreted monitors which were built soon after the war. Of these vessels one—the *Puritan*—is 296 ft. long, 60 ft. beam, and 18 ft. draft, with a displacement of 6,000 tons; the other four—the *Miantonomoh*, the *Monadnock*, the *Amphitrite*, and the *Terror*—are all of the same size, being 262 ft. long, 55 ft. beam, and 14 ft. draft, with 3,815 tons displacement.

These monitors are all built of iron, propelled by twin screws, and have but one short military mast for signaling purposes, with a top in which a Hotchkiss revolving cannon will be mounted.

The side armor for the *Puritan* has a maximum thickness of 12 in. and that of the other four ships a thickness of 7 in., while the turrets for all are plated with 11½ in. of steel, and each has an armored deck 2 in. thick, covered with 3½ in. of wood. The smoke-stack and ventilators will be protected by 10½ and 9½ in. of armor respectively, the conning-towers of the *Puritan* by 12 in., and those of the *Miantonomoh* and her class by 9 in. The freeboard of the *Puritan* will be 30 in. and that of the other four but 25 in. All will be armed alike. The main battery will consist of four 10-in. steel breech-loading rifles firing a projectile weighing 500 lbs., with a powder charge of 250 lbs. The secondary battery will comprise two 6-pounder, two 3-pounder, two 1-pounder Hotchkiss guns, and two Gatlings.

As a protection against torpedo attacks, nets are provided made of steel rings to be rigged out from the side some distance, hanging down into the water, with electric search lights for use at night.

Several important changes will be made as a result of the improvements made in naval architecture since the *Monitor* was originally designed. Formerly the turrets rested on the upper deck, from which they were lifted by a central spindle and revolved by steam to bring the guns to bear as desired. As modified, the turrets will pass through the upper deck and rest upon conical rollers on the next deck below, thus affording protection to the machinery and diminishing the liability to jam. Surmounting the turret is a conical armored pilot-house so constructed as to deflect a striking shot, and above the pilot-house, resting on iron stanchions over each turret, are light circular wooden houses containing quarters for officers in addition to those below decks. The tops of the turrets are connected by a hurricane deck where hammocks and boats will be stowed and the machine guns mounted. This deck is supported on combined stanchions and ventilators which allow for passage to the water which will flow across the main deck in heavy weather at sea. The *Puritan* is divided into 100 water-tight compartments, and the other ships each into 87.

These vessels will all be provided with sufficient quarters for officers and crew, with ample ventilation; they will have a full equipment of electric lights. The *Terror* is to have pneumatic apparatus for handling guns and turrets, and also pneumatic steering machinery.

These ships are to be used chiefly for coast defense, forming an important part of the system arranged by the Navy for that purpose.

The Thames River Bridge.

SEVERAL years ago the New York, Providence & Boston Railroad Company decided to have surveys made and plans prepared for a bridge, which should cross the Thames River between New London and Groton, Conn., and take the place of the steam ferry by which, for many years, the connection between its road and the Shore Line Division of the New York, New Haven & Hartford has been made. While this ferry was supplied with boats on which trains were transferred directly across the river, and answered its purpose very well for a number of years, the increase of travel between New York and Boston by the Shore Line and the sharp competition with the other rail lines made it a matter of importance to avoid the delay incident of the ferry transfer, and also the danger of obstruction of the crossing in the winter time. The surveys then made showed that a bridge crossing was perfectly practicable, but the proposition excited much opposition from the shipping interest, especially after the establishment of the United States Naval Station just above New London on the river. Difficulty was also experienced in arranging the conflicting interests of the railroad companies which were to build and use the bridge, and it thus happened that the execution of the plan was postponed from time to time.

All the difficulties in the way of the construction have now been overcome, however, and work has actually been commenced on the substructure of this bridge, for which the plans were made eight years ago.

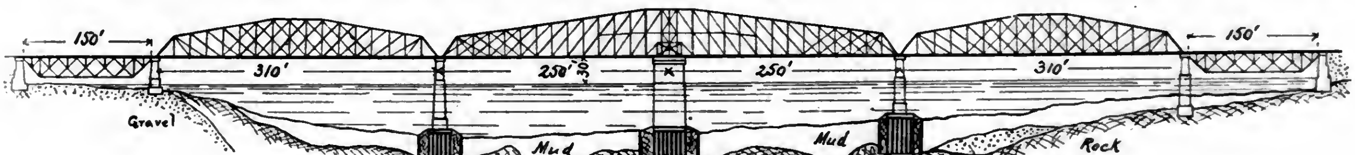
The bridge will cross the Thames River at Winthrop's Point, about one-half mile above the present ferry landing on the New London side. This is the narrowest place on the river, but is not the best for a bridge crossing, owing to the depth of water and the difficult nature of the bottom; it was chosen chiefly for the reason that a bridge there would not interfere with the free access of shipping to the New London wharves. The bridge is, however, below the Naval Station, and the length of the draw-span was fixed by the Government engineers so as to leave openings of sufficient width to permit the passage of the largest vessels now used or likely to be used in the Navy, as well as of the large steamboats which ply the river.

Beginning on the western, or New London side, the bridge will consist of one deck-span 150 ft. long; one fixed-through span 310 ft. long; one draw-span 502 ft. long, leaving a clear opening of 225 ft. on each side of the center pier; one through-span 310 ft. long, and one deck-span 150 ft. The total length of the superstructure will thus be 1422 ft. The draw-span, as will be seen, will be one of the largest, if not the largest, in the country, exceeding by some 70 ft. in length the great draw-span of the bridge over the Raritan between Perth Amboy and South Amboy on the New York & Long Branch road, which was at the time of its construction the largest in the world. The superstructure will be entirely of steel, and will present no special peculiarity of design. The draw-span will be operated by a steam-engine, and will be so

arranged as to open and close very quickly. The bridge will be built for a double track, and there will be a clear headway below it of 30 ft. at high tide, so that many small vessels will be able to pass without making it necessary to open the draw. The accompanying engraving is an outline sketch of the bridge, showing its general dimensions.

The substructure of the bridge required careful consideration on account of the great depth of water and mud found before a solid bottom was reached. The western abutment and pier No. 1 on the western side presented no special difficulties, as the depth of water at that side of the river is small, as shown in the sketch, and the masonry foundations will require merely the driving of a few short piles in the bed of coarse gravel, which at that point overlies the rock. Pier No. 2, pier No. 3 (the draw-pier), and pier No. 4, however, presented a difficult problem, the depth of mud and water at these points being 150, 128, and 130 ft. respectively. This depth was so great that it was considered that the ordinary pneumatic process of sinking caissons would involve too much difficulty and expense; and, to avoid this, another plan has been adopted. This is to sink into the mud at the bottom of the river an immense timber curb, fill it full of piles which are to be cut off even at the surface of the mud, and found the masonry upon a platform built on these piles. The mud within the curbs will be excavated or dredged out, and the spaces around the piles filled with concrete. The curbs will be sunk by loading them with ballast, for which purpose pockets will be left in them when built.

The curb for the center pier, No. 3 (the draw-pier), will be 71 ft. square and 79 ft. high; that for pier No. 2 will be



THE THAMES RIVER BRIDGE.

49 by 79 ft. in size and 85 ft. high, and that for pier No. 4 will be also 49 by 79 ft., but only 69 ft. high. The depth of water at all of these piers will not vary very far from 30 ft. above the mud bottom. In the accompanying sketch a general idea of the arrangement of these curbs is given. The curbs having been sunk into place and the piles driven and cut off at the proper level, the masonry will be built in open caissons and sunk into place, the bottom of the caisson forming a grillage for the support of the masonry. For pier No. 3 a base course of masonry 42 ft. square will be carried up with a slight batter to 38 ft., when it will change to the circular form of 36 ft. diameter. The masonry of this pier, measured from the grillage, will be about 75 ft. high. Piers Nos. 2 and 4 will be built in the same way, but will be, of course, of a different form, being about 42 by 8 ft. under the coping, and about 50 by 20 ft. at the base.

The masonry of pier No. 2 will be about 90 ft. high above the top of the piling, and that of No. 4 about 75 ft. Pier No. 5 requires no special description, the depth of water at that point being only about 20 ft., and the mud about the same, so that it has only to be carried down about 40 ft. before reaching a solid bottom. The east abutment also, like the west one, will not be difficult of construction, the mud at that point being 14 ft. and the water 12 ft. above the solid bottom. Both these piers will be built in open caissons sunk on a concrete foundation made by a timber crib sunk through the mud to the rock bottom. All the masonry will be of granite.

The preliminary surveys and plans for the bridge were made by Mr. Alfred P. Boller, of New York, who has had entire charge of the work since the construction of the bridge was first proposed. The contract for the bridge has been let to the Union Bridge Company of New York. That Company will build the superstructure, and has sublet the contract for the foundations and masonry to Mr. Alexander McGaw, of Philadelphia. The surveys for the bridge have been of a very complete character, and have included an immense number of borings at different points along the river, made in order to ascertain the exact nature of the bottom. As above said, however, the final location of the bridge was determined rather by other considerations than by the nature of the ground.

The western approach to the bridge will be made by a line running from the present Union Station in New London through the eastern part of the city, nearly parallel with the track of the New London Northern Railroad, and turning eastward by a sharp curve nearly opposite the western end of the bridge; the New London Northern track will be crossed overhead near the bridge. On the eastern side a new line will be built from the end of the bridge to Noank, on the New York, Providence & Boston Railroad, which will be somewhat shorter than the present line, and will be also a better line, avoiding several of the sharp curves in the old road. The present steam ferry will be abandoned, at least for the transfer of cars, as soon as the bridge is completed.

FURNACES FOR BURNING LIQUID FUEL.

(*Continued from page 219.*)

3. THE nozzle sprinkler of Aydon, Wise & Field was first tried in England in 1866, and is one of the oldest methods for burning liquid fuel. In this burner, which is shown in fig. 20, the oil entered the sprinkler from a vertical pipe through an opening of about $\frac{1}{8}$ in. in diameter, flowing continuously from a tank at a higher level. It was forced into a discharge pipe by a stream of superheated steam escaping from a horizontal pipe, which sucked in air from a funnel on top of the sprinkler. The oil, steam, and air were discharged together through the cone-shaped mouth of the sprinkler into the fire-box and struck against a bridge of fire-brick, which served to still further distribute the stream and expose it to the heat, thus securing full combustion. The supplies of oil, air, and steam were

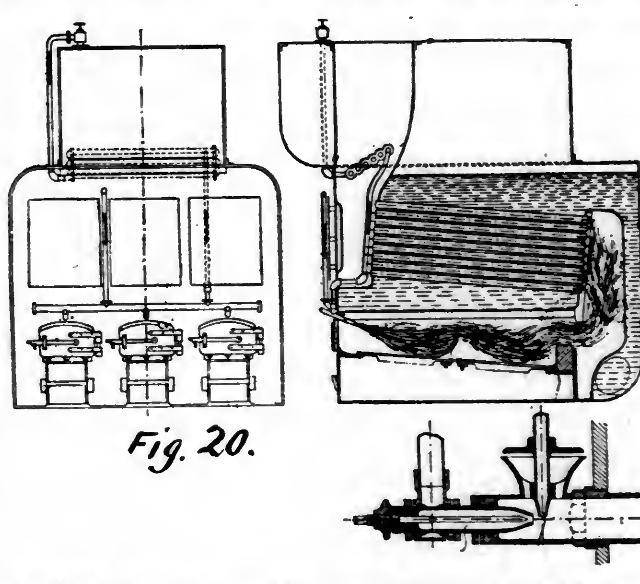


Fig. 20.

regulated separately. This contrivance was tried for some time, but did not come into any extended use.

The nozzle sprinkler of Aydon and Selwyn, shown in fig. 21, was a modification of the apparatus mentioned above, and was used in a marine boiler in some trials conducted by the English Admiralty in 1868. The chief modification from the former apparatus was an arrangement made by

which the oil and steam met at an acute angle instead of a right angle. This was tried both with and without bridges in the fire-box, and the trials were so far successful that the apparatus was placed in the boilers of the British naval

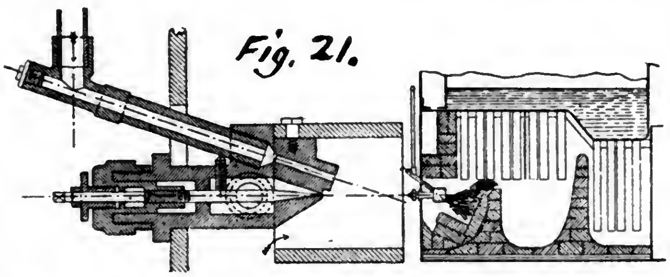


Fig. 21.

steamer *Oberon*. In this boiler it is claimed that very satisfactory results were obtained, and practically a perfect combustion of the oil.

The experiments were not continued, however, probably owing to the high price of oil at that time. It is to be noted, however, that these inventors first introduced nozzle sprinklers, to which a return has now been made after trying a number of other methods.

The nozzle sprinkler of Korting, shown in fig. 22, was introduced in 1876, and was arranged to be used in boilers without any alteration of the fire-boxes. All that was necessary was to fasten it to the side of the fire-door. In this device steam is admitted into the sprinkler through the opening *A*, and enters a compartment from which it

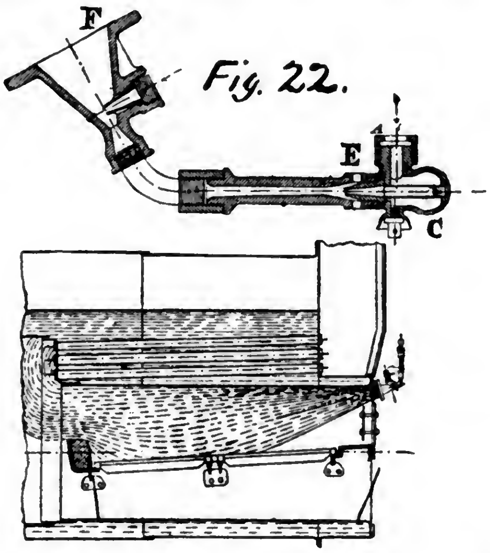


Fig. 22.

escapes through small holes in a copper tube into the nozzle. Any condensed water is caught in a small, bell-shaped attachment, from which it may be drawn by the valve *C*. The steam entering through this nozzle draws in

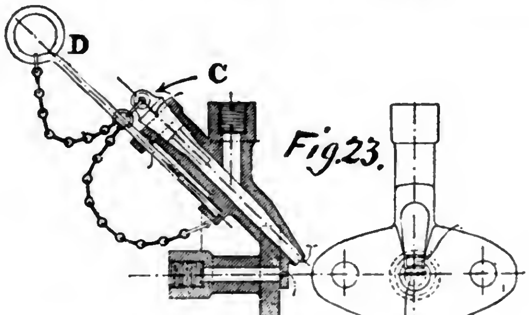


Fig. 23.

air from the openings *E*, and the steam and air together vaporize the oil in a spray from the mouthpiece *F*. The oil flows into the mouthpiece through the openings shown in the side, which are of about $\frac{1}{4}$ in. in diameter. The flow of oil, steam, and air can be regulated by valves. The flame is blown into the fire-box at an angle, as shown in the section of the boiler. The difficulty with this apparatus was, apparently, that the steam jet was not sufficiently powerful, and that the oil was not sufficiently separated to secure perfect combustion.

Some years later Korting introduced a modification of this apparatus, which is shown in fig. 23. In this the oil flowed out of a slit-like opening and was vaporized by the

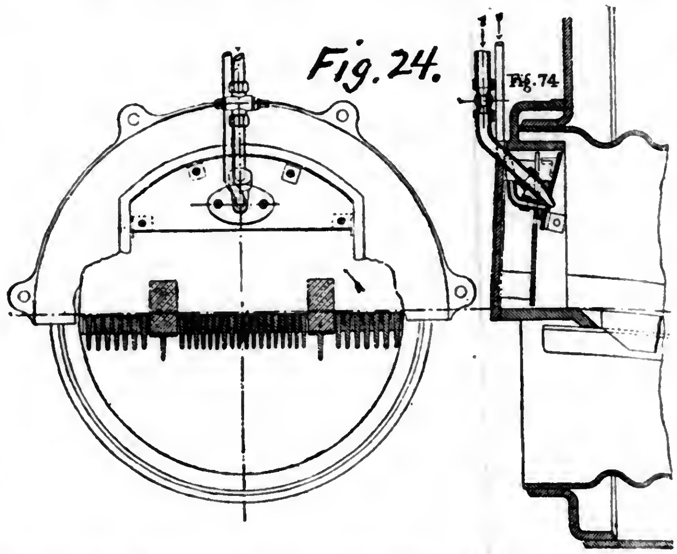


Fig. 24.

steam jets, which met it at an acute angle. The steam issued from several small orifices from $\frac{1}{16}$ to $\frac{1}{8}$ in. in diameter. The stopper *C* could be drawn out should the nozzle become stopped up, and the opening could be cleaned out by means of the needle *D*, which was attached to it by a chain. In fig. 24 this apparatus is shown as applied to the furnace of a marine boiler.

Dickey's nozzle sprinkler was patented in the United States in 1878, and was tried on a locomotive on the Long Island Railroad. Crude petroleum was used, which was carried in a tank in the tender. From this tank two pipes led to the fire-box, each of them ending in a sprinkler,

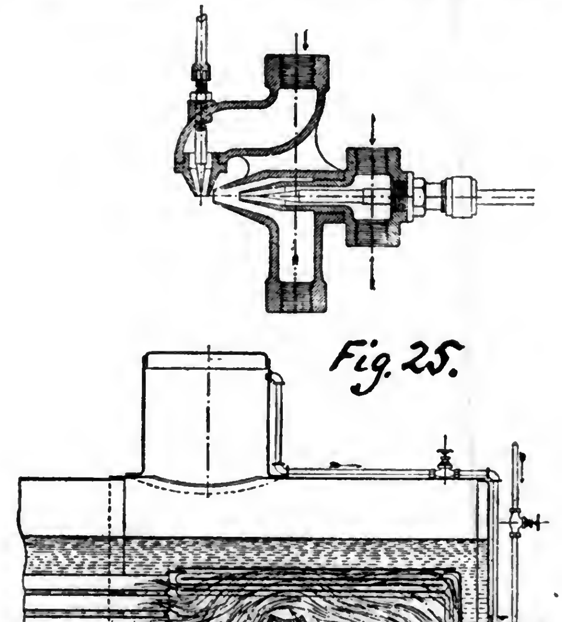


Fig. 25.

from the nozzle of which oil issued at a low pressure. Superheated steam was introduced by a nozzle placed at right angles to the oil-pipe, and air was drawn in through a pipe projecting underneath the fire-box by the action of the steam jet. The oil, steam, and air were blown against

a number of cast-iron plates arranged like Venetian blinds, through the openings of which additional air was admitted. These openings could be enlarged or reduced at pleasure. This apparatus, which is shown in fig. 25, was placed in a grate of an ordinary coal-burning engine, and, it was claimed, secured a very complete and even heating of the fire-box. At the trials it was said the combustion was very good; no smoke escaped through the stack. The trials were not continued, however, and the apparatus was not further introduced. In this case, as in many others, the relative prices of coal and oil probably had much to do in determining the result.

A nozzle sprinkler arranged by Mr. Urquhart was tried in 1874 on the Gryasi-Tsaritzin Railroad in Russia; it is shown in fig. 26. In this the oil was carried through a tube into a horizontal pipe running along the wall of the

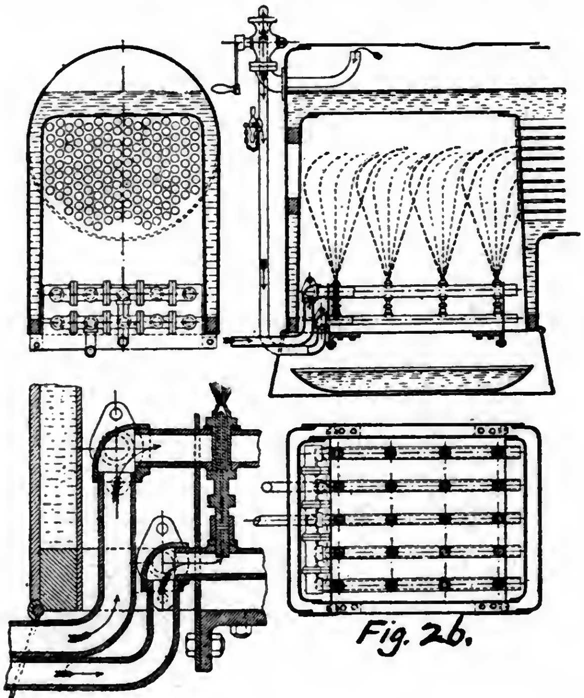


Fig. 26.

fire-box, to which five other horizontal parallel pipes were connected. Under each of these pipes was a steam-pipe

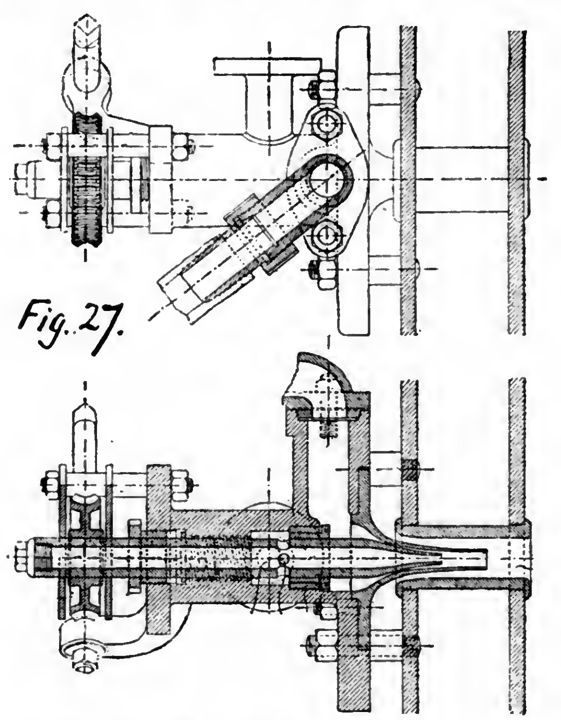
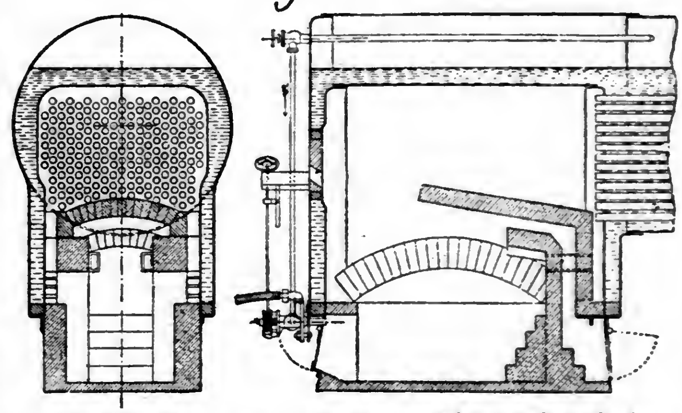


Fig. 27.

taking steam from the boiler, and so arranged that steam and air would pass through the nozzle and carry the oil in a circular spray of vapor into the fire. Any oil unconsumed dropped into a pan of water carried in the ash-pan. This arrangement was not found to be economical, however, and it was subsequently given up for an improved system devised by Mr. Urquhart.

A later device of Urquhart is shown in fig. 27. In this the oil passes from tanks in the tender by means of a tube and a pipe into the sprinkler. The non-superheated steam leaves the dome of the boiler and enters the sprinkler; it passes through orifices into the interior of a bronze spindle and escapes through the front of the nozzle. A spiral wheel which moves on a spring in a groove regulates the outlets for the oil. To obtain the requisite air the sprinkler is fixed so as to protrude into a pipe-rest, and a space of about 1 in. is allowed between the flange of the sprinkler and the plate of the boiler. The oil and steam are separated inside the sprinkler by means of a box filled with asbestos packing, which latter has to be renewed about once a month. The admission of steam is regulated by a special valve in the pipe. The results were found to be so good that 140 locomotives on the Gryasi-Tsaritzin Railroad are now fitted with it. Should this sprinkler get stopped up for any reason the spindle has only to be screwed back, and the oil will force the carbonized particles into the fire-box. Urquhart has also protected the walls of the pipe against the flames, and prevented all the deteriorating action on the boiler which their direct action entails, by lining the inside of the fire-box with brick, as shown in fig. 28. Here the sprinkler is placed low down, and blows into a furnace chamber built into the fire-box and covered with a vaulted roof, which slants off

Fig. 28.



in the direction of the tube plate. The brickwork does not lean against the wall of the fire-box, but is about 2 in. from it, so that these walls may not be lost to the heating surface. The flame beats from the furnace chamber against what used to be the fire-door, now bricked up (except a small peep-hole), and reaches the tubes through an opening in the roof of the chamber at this point. Two channels are built into the walls of the furnace chamber, and lead a portion of the heating gases to the lower surface of the tube-plate, as well as into the spaces between the brickwork and the outer walls of the fire-box, so as to give these an efficient heating surface. The requisite air is forced into the furnace by the sprinkler, and more air is admitted by the ash-pan dampers, which are regulated by chains and chain-wheels. The air entering at the front ash-pan damper passes through a channel, and is warmed before being admitted to the gases. Complete combustion of the oil is insured by fitting the fire-box with tiles, which, being non-conductors of heat, keep the walls of the fire-box at an equal temperature, and even re-light the oil-stream should a short interruption of work occur. This also greatly simplifies management.

[Urquhart's method has been tried on the Pennsylvania Railroad. It was illustrated and described in the JOURNAL for August, 1887.]

Spakovski's nozzle sprinkler, shown in fig. 29, has been used on steamers on the Caspian Sea. The liquid fuel, in this case oil residuals, flows out of the inner nozzle, which protrudes into the mixing pipe 0.04 in.; the steam escapes through the circular opening surrounding this nozzle. Air is admitted through holes in the circumference of the mixing-pipe; the mixing pipe prevents the great air expansion

of the steam jet and thus slightly aids the vaporization of the oil; but this is not done so efficiently in the case of the Spakovski apparatus as in that of Urquhart's latest improvement. The steam jet surrounding the oil only acts

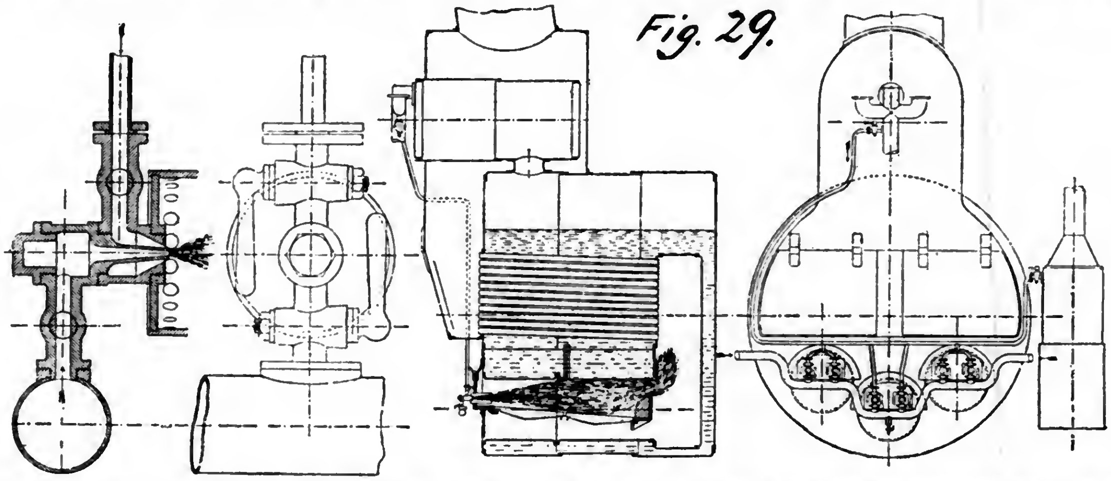


Fig. 29.

strongly from underneath; the upper part expands without materially aiding the vaporization, so that by looking through a piece of blackened glass drops of fluid oil can be observed falling into the furnace, where they are burnt up in their fluid state. The flame has a broom-like shape,

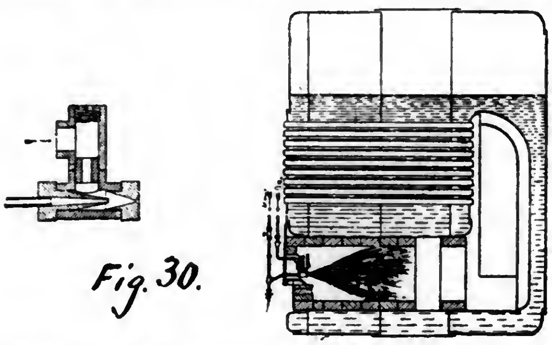


Fig. 30.

and is very long, so that it acts most forcibly on the fire-bridge, and heats the other parts of the fire-box only by radiation, and even that rather unequally. In cases where the furnaces are very large one sprinkler is inadequate,

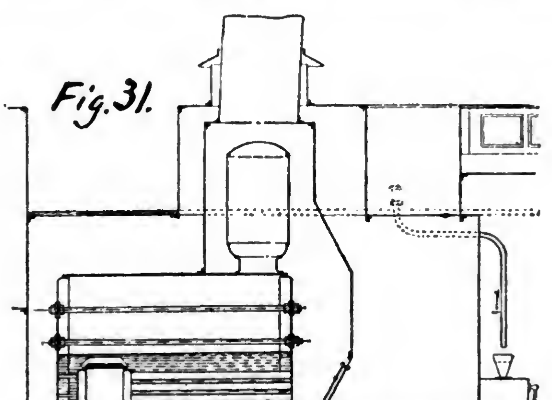


Fig. 31.

and two or three have to be fitted, which causes complication. The supply of oil and steam is regulated by means of separate valves for each sprinkler. The first trials with this apparatus showed an excessive consumption of oil, but with subsequent improvements made much better results were obtained.

Sadler's nozzle sprinkler, shown in fig. 30, is a very simple one. It consists of two small bronze nozzles, which are screwed on to the opposite ends of a **T**-shaped malleable iron pipe. Another **T**-shaped pipe is screwed into the third orifice of the first, and the horizontal pipe of this admits the oil, while the perpendicular end admits the air. The steam-pipe, before reaching the sprinkler, is conducted into the furnace, and forms a winding pipe there, through which the steam is passed to get superheated. The oil and air enter the sprinkler through the same orifice, and in the space between the nozzles. The furnace is lined with fire-proof brick. The oil and steam supplies are regulated by separate taps or valves. This sprinkler was tried with tar and heavy tar oils, with which a large tank was filled. Steam-pipes passed through this tank, so

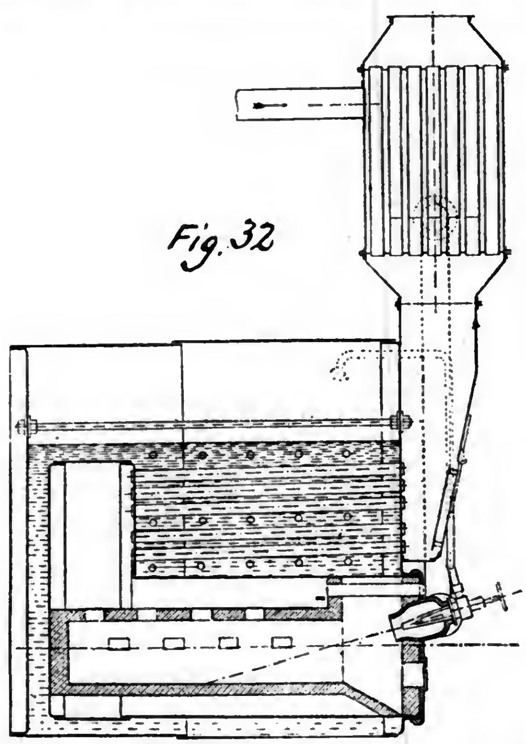


Fig. 32

as to melt the tar. The tar then flowed into a smaller vessel covered with brass gauze, so that all coarse impurities that might stop up the sprinklers were arrested. The tar entered a pipe with a clear width of 2 in., which had a steam-pipe 0.4 in. in diameter inside it, and flowed from thence into the sprinkler. On entering this the tar had the appearance of a dark and rather thick mineral oil.

The nozzle sprinkler of d'Allest was tried in 1885 on the French steamer *Aude;* it is shown in fig. 31. Both the furnaces of the boiler were lined with fire-proof brick, which rested on the old coal-grate. Two sprinklers blew oil into each of the furnaces. The results were good so far as combustion was concerned, but the sprinkler consumed an abnormally large quantity of steam, as much as from 8 to 10 per cent. of the entire steam consumption. D'Allest

then tried to vaporize the oil by means of compressed air instead of steam, to avoid the enormous loss of the latter. But the first experiments of this kind were not successful, because the blowers would not give sufficient pressure. In 1886 further experiments were made. In these the air was pressed by an air-pump into a cylindrical tank, and was conducted from thence to the sprinklers, where it must have retained a considerable pressure. The oil flowed from a tank into the sprinklers in the boiler. The results of these experiments showed that the combustion of oil is much more perfect when it is vaporized by compressed air than when vaporized by steam, as, indeed, was proved by the increased whiteness of the flame. The best results were obtained with hot air ; in vaporizing with cold air the walls of the furnace must be lined with fire-proof brick, otherwise the flame is nearly extinguished. The weight of air necessary to work the sprinkler amounted to about 5 per cent. of the steam generated.

Experiments were also made with the nozzle sprinkler of d'Allest to see whether oil fuel could be used in cases where an artificial draft was raised, and when it is especially necessary, as with the boilers of torpedo-boats, to generate as great a weight of steam as possible per square meter of heating surface per hour. For this purpose the arrangements shown in fig. 32 were made. A clay receiver was placed in the furnace and two sprinklers were fitted in front of it. The vaporization could be effected either by steam or compressed air. The artificial draft was produced by a blower in a heater in the throat of the chimney, and was then conducted into a box which encased the two sprinklers. The results obtained in these experiments were very satisfactory, it is said.

D'Allest subsequently conducted a series of experiments on the torpedo-boat *La Chevrette*, under the direction of the French Ministry of Marine. He at first tried to use compressed air to vaporize the oil as well as to supply draft, but this proved unsuccessful and he had to return to the use of steam. In a torpedo-boat boiler it is necessary to obtain a high evaporation in a small boiler. D'Allest claims that he secured this, and further, that he had complete combustion of the oil both with natural and forced draft. He stated that the result of his experiments was that, with oil as fuel, a boiler one-fifth smaller could be used than with coal, a great advantage in a vessel of this class. An incidental advantage also was that when burning oil with forced draft the flues were never stopped up, as they frequently were with coal.

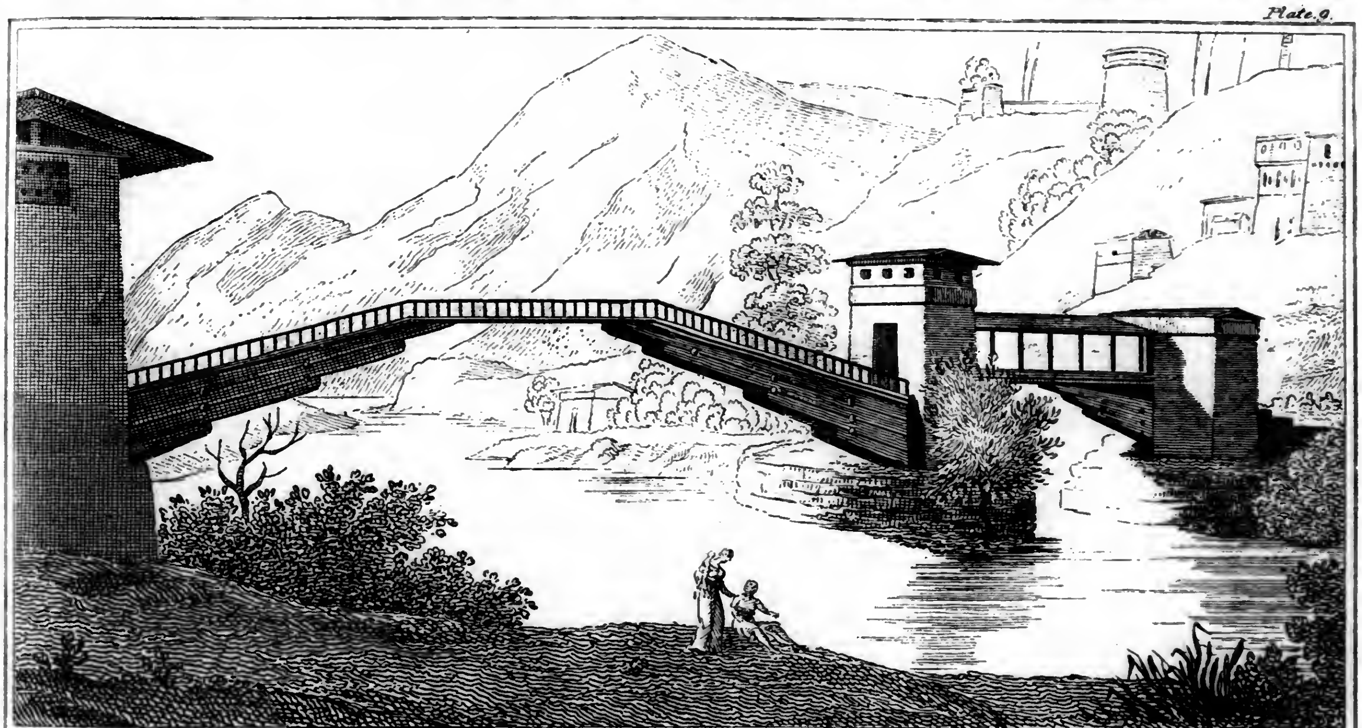
There seems to be no doubt of the superiority of liquid fuel in many cases of this kind, where the room allowed both for boilers and for storage of fuel is limited.

An Ancient Cantilever Bridge.

In the very curious "Treatise on Bridge Architecture," published by Thomas Pope in 1811 (to which reference was made last month), there is given an engraving and description of a bridge which is, so far as we know, the oldest example of a cantilever bridge on record. The description is taken by Mr. Pope from a still older work, Turner's "History of the Embassy to Thibet;" and though the date of the structure is not definitely given, it would appear from the references made that it must have been built more than two centuries ago. We reproduce herewith the illustration and description.

The Bridge at Wandipore is of singular lightness and beauty in its appearance. It is composed entirely of fir, and has not the smallest piece of iron, or any other metal, to connect its parts ; it has three gateways ; one on each side of the river, and another erected in the stream, upon a pier, which is pointed like a wedge toward the current, but is on the opposite side a little convex ; below it, the eddy produced by the reunion of the divided water has thrown up a large bed of sand, on which grows a large willow, that flourishes extremely. The gateway on the Tassisudon side is a lofty square stone building with projecting balconies near the top, bordered by a breastwork, and pierced with a portcullis. The span of the first Bridge, which occupies two-thirds of the breadth of the river, measures 112 ft. ; it consists of three parts, two sides and a center, nearly equal to each other ; the sides having a considerable slope, raise the elevation of the center platform, which is horizontal, some feet above the floor of the gateways. A quadruple row of timbers, their ends being set in the masonry of the bank and pier, supports the sides ; the center part is laid from one side to the other. The beams and planks are both of hewn fir ; and they are pinned together by large wooden pegs. This is all the fastening I could observe ; it is secured by a neat light rail. The Bridge, from the pier to the hill, is horizontal, and the beams rest on the pier and on a triple row

Plate. 9.



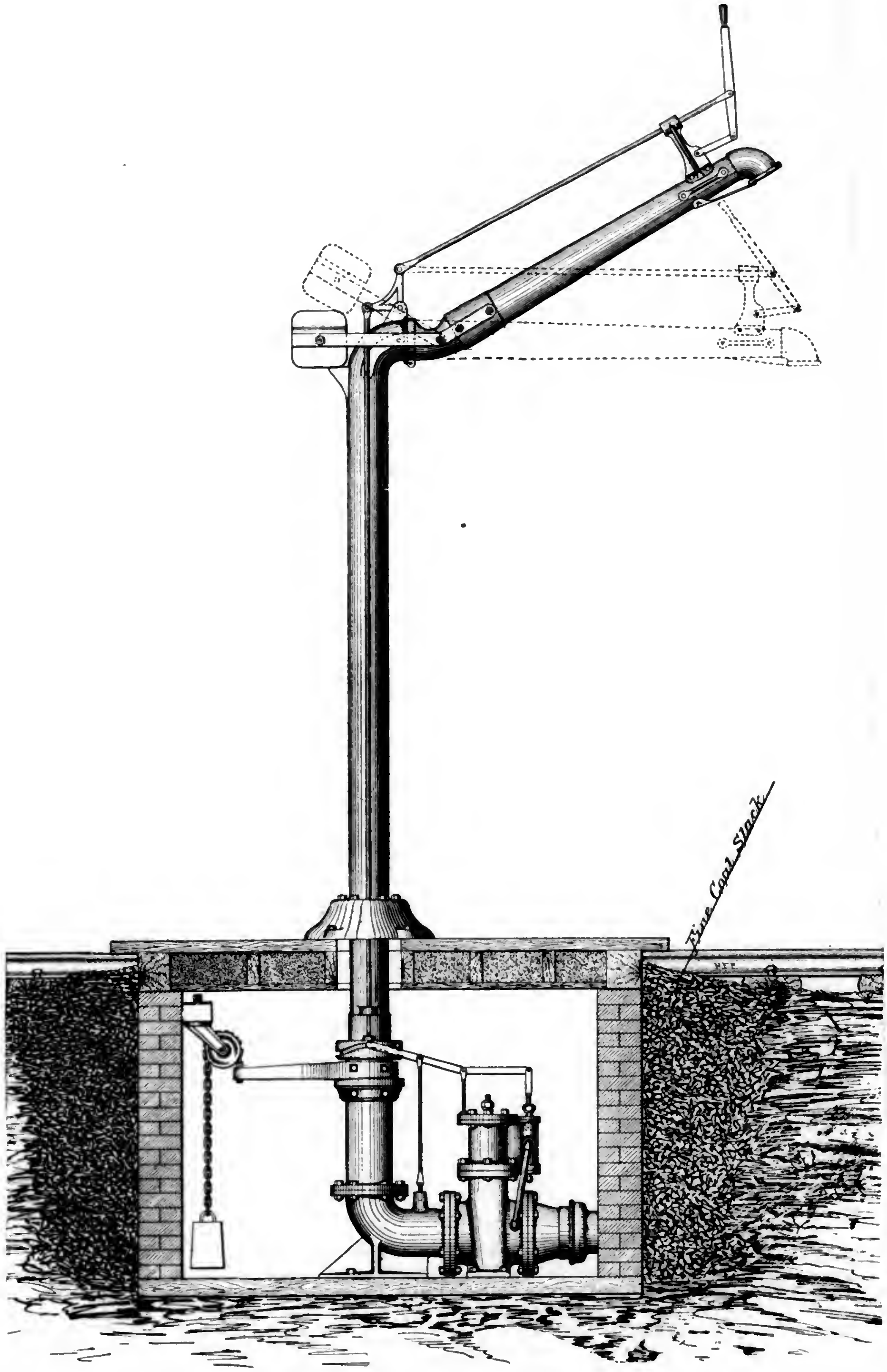
T. Pope del. C. Rollinson sc.

The Bridge at Wandipore

of timbers let into the bank; it has a penthouse over it, which is covered with shingles. The sound state of this Bridge is a striking instance of the durability of the turpentine fir; for, without the application of any composition in use for the preservation of wood, it has stood exposed to the changes of the seasons for near a century and a half, without exhibiting any symptoms of decay, or suffering any injury from the weather.

Improved Automatic Stand-Pipe.

THE accompanying illustration shows an improved form of railroad stand-pipe recently introduced by the Sheffield Velocipede Car Company at Three Rivers, Mich. Its construction will be readily understood from the engraving. It includes the main features of the plain pipe heretofore



IMPROVED AUTOMATIC RAILROAD STAND-PIPE.

Made by the Sheffield Velocipede Car Co., Three Rivers, Mich.

made by the same company, which is now extensively used. These include the flexible joint and elevating spout, combined with a rotating column; the elevation of the spout retains the drip, so that the ground around the stand-pipe is not wet and muddy in summer or covered with ice in winter, the column being freed from water by a waste valve which works automatically.

The special feature of the automatic pipe is the use made of the pressure always on the pipe to open and close the valve. This is effected by the use of a cylinder above the valve, in which is a piston connected to the valve itself; this piston can be moved up or down at will by means of the auxiliary valve attached to the main cylinder, the operator or fireman being thus enabled to throw the pressure of the water on either side of the piston, as desired.

The difficulty usually found with stand-pipes operated by the fireman from the tender has been the amount of mechanism necessary to work the valve, and the strength required to open and close it. In this pipe the machinery is very simple, and is only required to operate a small auxiliary valve which admits water into the main cylinder, and thus moves the valve proper. The auxiliary cylinder is so arranged that the valve of the stand-pipe may be opened rapidly and closed very slowly, as desired; this obviates the shocks given to the pipe by too rapid closing, and at the same time gives a quick opening.

The spout is balanced by a counterweight, which holds it in an elevated position when not in use, as shown in the cut. The same kind of a device also holds the pipe in line with the track when it is not needed for watering, thus obviating all chance of the spout being blown around by wind or thrown around by careless or malicious persons into a position where it might be struck by a passing train.

The distinctive features of this form of stand-pipe are covered by patents. It is in use at several points with excellent results.

A Marine Brake.—Experiments have been recently made on the Seine, in the stoppage of steamers in motion, by means of a "cable-anchor" invented by M. Pagan. This is a cable having on it a series of canvas cones, which open out by the action of the water, and close again when drawn in the opposite way. The steamer *Corsaire*, running 13 knots, was stopped each time by the apparatus in seven or eight seconds, and in a space of 26 to 30 ft. at the most. For comparison, the steamer, running full speed, was stopped in the usual way, by reversal of the engines. This took at least 34 seconds, and the space was 350 to 360 ft. It would thus appear that M. Pagan's apparatus effects the result in less than a tenth of the space, and a fourth of the time, of the ordinary method.—*Nature.*

M. Pagan's device may be very effective in preventing collisions, but it must make things rather lively for the passengers.

CATECHISM OF THE LOCOMOTIVE.

(Revised and enlarged.)

BY M. N. FORNEY.

(Continued from page 228.)

CHAPTER XII.

THE CYLINDERS, PISTONS, GUIDE-RODS, AND CONNECTING-RODS.

QUESTION 300. *How are the steam cylinders constructed?*

Answer. They are made of hard cast iron, and have the steam and exhaust ports and valve-seats cast with them. The harder the iron the better will the cylinders withstand the wear of the pistons and valves, but they must at the same time be made soft enough, so that after they are cast the inside can be bored out perfectly cylindrical, the ends turned off, the bolt-holes drilled, and the valve-seats planed smooth.

Fig. 177 represents a longitudinal section through the center of the cylinder and steam-chest. Fig. 178 is a plan of the same parts with the cover of the steam-chest and the valve removed. Fig. 179 is a front end view, and fig. 180 a transverse section,

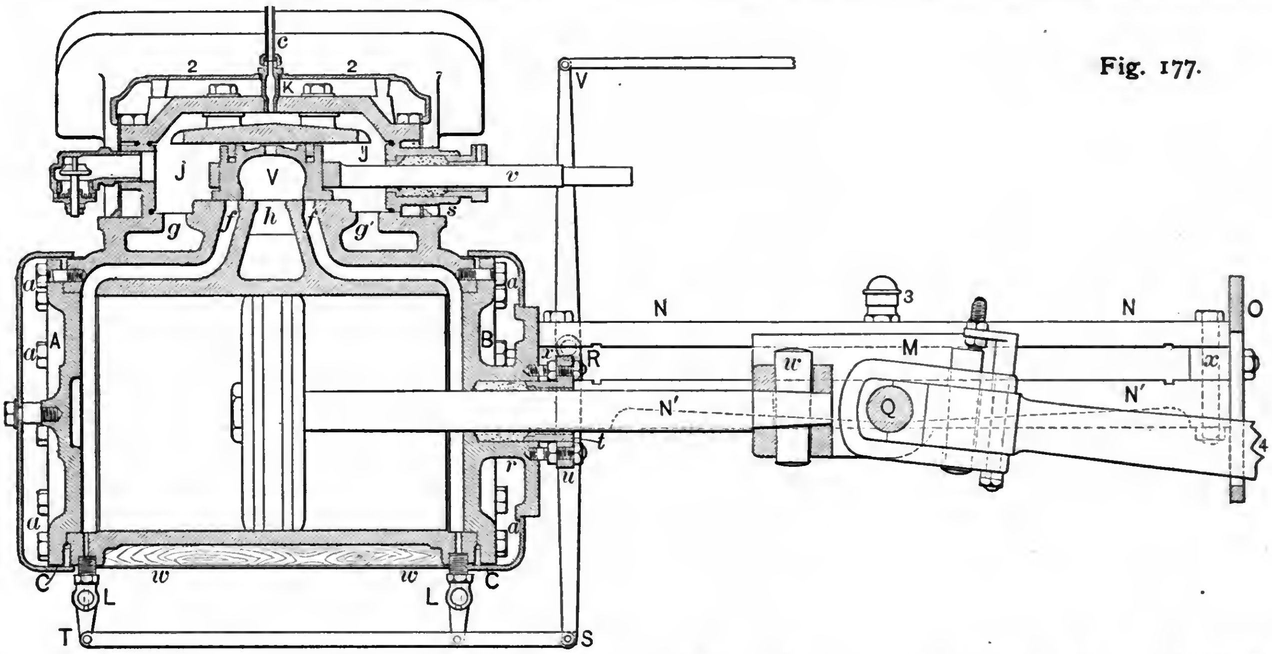


Fig. 177.

through *c d*, fig. 178, of the cylinder. Fig. 181 is a transverse section through the guide bars *N N*, fig. 178, looking backward towards the cross-head and cylinder. The same letters indicate like parts in the different views.

The cylinders of locomotives in this country are now universally placed on the outside of the wheels, as has already been described. In order to fasten them securely together and to the boiler, they are attached to what is called *bed-plates* or *bed-castings*, *D D*, figs. 179 and 180, which are placed between them. Sometimes the bed-castings are made in a separate piece, and the cylinders are then bolted to it on the outside, about at the dotted lines *l m*, fig. 179. The usual practice now is to cast one-half of the bed-casting with each cylinder, as shown in the engravings, and then bolt them together at the line *i j*, which is the center of the engine. The bed-castings are also bolted to the smoke-box by the flanges *E E*. The cylinders are bolted to the frames *F F* with bolts, *m* and *k*, figs. 179 and 180.

After the cylinders are bored out and the ends turned off, *heads*, *A* and *B*, fig. 177, are fitted with steam-tight joints to each end. These heads are fastened with bolts and nuts, *a a a*, to flanges, *C C*, fig. 178.

QUESTION 301. *How is the steam conducted to and from the cylinders?*

Answer. Two pipes or passages are cast in each cylinder, the one, *G*, fig. 180, for admitting steam into the steam-chest, and the other, *H H'*, for exhausting it from the cylinders. The one, *G*, is called the *steam-passage*, and the other, *H H'*, the *exhaust-passage*. The steam-passage terminates at one end with a round opening, *G*, figs. 178 and 180, to which the steam-pipe *o*, fig. 90, is attached inside of the smoke-box. At the other end it divides into two branches, *G' G'*, shown by dotted

lines in fig. 178, each of which terminates in an opening, *g g'*, inside of the steam-chest. The steam is thus delivered at both ends of the chest, and can pass freely into each of the steam-ports when they are open. By making the cylinders in this way, they are exactly alike for each side of the engine, or, to use a shop phrase, there are "*no rights and lefts*," so that a cylinder casting can be used for either side of the engine. This method of making cylinders has been adopted by nearly all the principal builders in this country.

QUESTION 302. *How is the steam-chest constructed?*

Answer. It usually consists of two castings, one of which, *J J*, figs. 177, 178, 179, and 180, is a square cast-iron box made open at the top and bottom. This rests on the top of the cylinder casting and is joined to the latter with a steam-tight joint. On top of it is a cast-iron cover, *K*. The steam-chest and cover are held down by bolts, *p p*, which are screwed into the cylinder casting and have nuts on top.

QUESTION 303. *How are the slide-valves make to work steam-tight on the valve-seats?*

Answer. They are first planed off smooth, and then filed and scraped until the two touch each other over the whole of their surfaces in contact. The valve-stem *v*, fig. 177, works steam-tight through a stuffing-box, *s*, on the steam-chest.

QUESTION 304. *How are the valves and pistons oiled?*

Answer. The oil is usually introduced into the steam-chest through a pipe *c*, which is connected with a cock in the cab called the *cylinder oil-cock* or "*oiler.*" From this cock the oil flows through the pipe and down upon the valve and is conducted by suitable holes and channels to the valve-face and from there through the steam-ports to the cylinder and piston.

Sometimes the valves are oiled by pouring oil or melted tallow into the oil-cocks when the steam is shut off from the steam-chests and cylinders. When the pistons are working in the cylinders without steam, they create a partial vacuum, so that if oil is then poured into the oil-cocks it will be sucked into the steam-chests, or, in other words, it will be forced in by the pressure of the air above it. A shelf 105, fig. 165, is attached to the boiler to receive an oil-can filled with oil or tallow, which is thus melted or kept in a fluid condition by the heat of the boiler.

QUESTION 304. *How are the cylinders and steam-chests protected so as to prevent, as far as possible, the heat in the steam from being lost?*

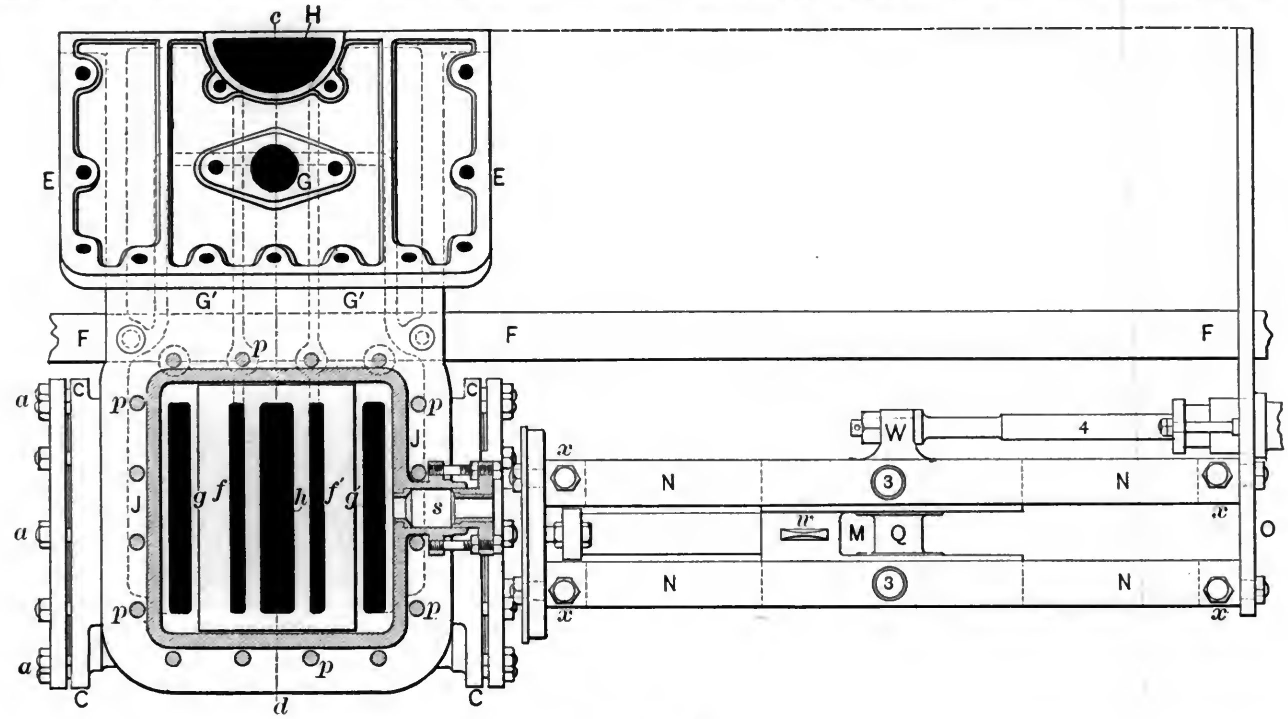


Fig. 178.

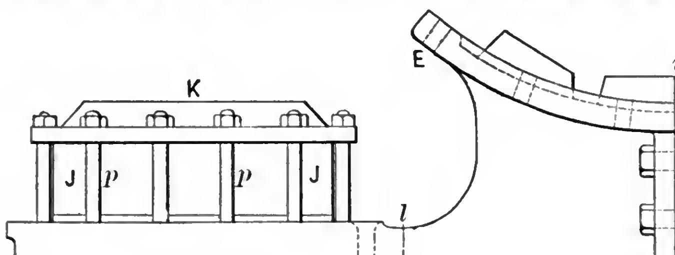


Fig. 179.

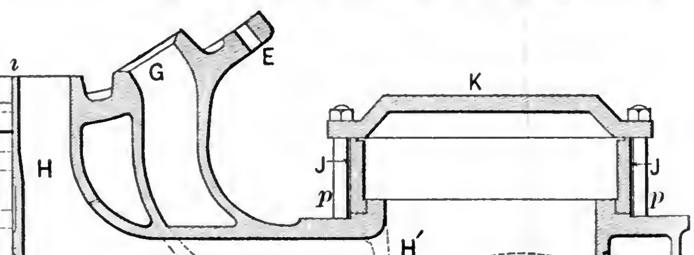


Fig. 180.

Answer. The sides of the cylinders are covered with wood, *w w w*, fig. 180, called the *cylinder lagging*, and the wood is covered outside with Russia iron, which is called the *cylinder-casing*. The ends of the cylinders have light metal covers, called *cylinder-head covers*, shown in section at *a a*, fig. 177, made of cast iron, brass, or sheet metal. The steam-chest has a similar cover, 2 2, fig. 177. Sometimes coarse felt is used for lagging the cylinder and steam-chest.

QUESTION 305. *For what purpose are the cocks L L, figs. 177, 179, and 180, at each end of the cylinder, used?*

Answer. They are used to exhaust the water which collects in the cylinders. When the engine is not working the cylinders

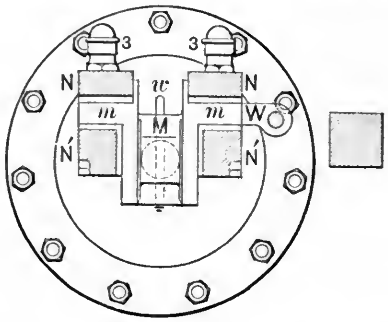


Fig. 181.

and steam-pipes are all cooled off, so that when steam is first introduced into them a great deal of it is condensed until they become warmed. Water is also frequently carried over from the boiler with the steam. When this occurs the boiler is said to *prime*, or to "*work water*." This water and that produced by the condensation of steam collect in the bottom of the cylinder and will not escape through the exhaust-pipes until the piston moves up so near to the end of the cylinder that the water will fill the whole space between it and the cylinder-head. As has already been stated, it will then escape so slowly that the momentum of the piston and other machinery is liable to "knock out" the cylinder-heads or even break the cylinder itself. The cocks *L L*, called *cylinder-cocks*, are therefore placed in the under side of the cylinder, so that when they are open if there is any water in the cylinder it will escape through them. They are therefore always opened when the engine is starting, or at any other time when there is any indication that there is water in the cylinders.

QUESTION 306. *How are these cocks opened and closed?*

Answer. A shaft, *R*, fig. 177, which extends across the frames, has an arm, *R S*, fig. 177, at each end. These arms are connected by rods, *S T*, with the handles of the cylinder-cocks. The shaft also has a vertical arm, *R V*, the upper end of which is connected by a rod with the cab. At the end of the rod is a suitable handle by which the cocks can be either opened or closed at pleasure by the locomotive runner.

QUESTION 307. *How is the piston-rod fastened to the piston?*

Answer. It fits into a straight or tapered hole in the piston-head, in which it is fastened either with a key or by a nut on the front side of the piston.

QUESTION 308. *How are pistons constructed?*

Answer. They are made in a variety of ways. Figs. 182 and 183 represent a form of piston which has been used for many years and is still preferred by some engineers. Fig. 182 shows the front side of the piston with one-half of the follower-plate removed, and fig. 183 is a longitudinal section.

They are made of two cast-iron pieces, *B* and *C*, fig. 183, the one, *B*, called the *piston-head* or *spider*, to which the piston-rod *D* is attached. The other part, *C*, called the *follower-plate*, is bolted to the piston-head by the bolts *f f*, called *follower-bolts*.

QUESTION 309. *How are pistons made to work steam-tight in the cylinder?*

Answer. The old way of making pistons is shown, as noted above, in figs. 182 and 183. Pistons of this kind have two rings, *A A*, called *packing-rings*. These rings are turned of the same size or a little larger in diameter than the cylinder. They are then cut open at one point in their circumference so that they can be pressed apart or expanded by the springs *a a*, called *packing-springs*, on the inside of the rings. These springs are pressed out by the nuts and bolts *b b*, called *packing-bolts* and *packing-nuts*, so that when the rings wear they can be expanded so as to fill the cylinder completely. The place where the one ring is cut is placed opposite that of the opening in the other ring, or they are made to *break joints*, as it is called. This is done to prevent the steam which leaks through the opening where the one ring is cut from passing through to the other side of the piston. These rings are usually made of brass and have grooves, *c c*, fig. 183, turned in them, which are filled with what is called Babbitt's metal. This metal is used because it is less liable to scratch the cylinders than brass alone. Another ring, *l l*, made of cast iron and as wide as the two brass rings, is placed inside of the latter and is intended to furnish a bearing for the springs, and thus distribute their pressure equally on the packing rings. This iron ring is also cut open at one point. The follower-bolts, *f f*, are screwed into brass nuts, *N N*, which are contained in cavities cast in the lugs, *L L*, on the piston-head. These brass nuts are used to prevent the bolts from rusting fast, as they are liable to when screwed into the cast iron of which the piston-head is made.

QUESTION 310. *What other kinds of pistons are there?*

Answer. A number of different kinds are used with packing rings of various forms. These are usually made larger in diameter than the inside of the cylinders. After being cut apart they are compressed so as to enter the cylinders, and their own elasticity or tendency to spring apart keeps them tight. Figs. 184, 185, and 186 represent one form of this kind of packing. It consists of a main ring, *l l*, which has two grooves turned in it which receive the two rings *A A*, which, as explained, are made somewhat larger than the cylinder. They are cut apart and are held in the grooves by a flange on the piston-head on one side, and by the follower-plate on the other. The ring *l l* is not cut open, but is left solid, and the weight of the piston causes this ring to bear on the bottom of the cylinder. The openings *b b*, where the rings *A A* are cut apart, are placed at the bottom of the piston, as shown in figs. 184 and 186. Fig. 186 is an inverted plan of the piston, and shows the position of the openings. As the ring *l* bears on the bottom of the cylinder it keeps the piston tight at that point, so that any steam which may leak through either of the openings *b b* could get no further than the ring *l*. The elasticity of the rings *A A* causes them to bear against the top and sides of the cylinder and in that way keep them tight; *a a* are pins to prevent the rings *A A* from turning.

In some other pistons the packing rings are cut into sections and are either pressed out by some form of springs, or steam is admitted to the grooves in which they are held so as to press

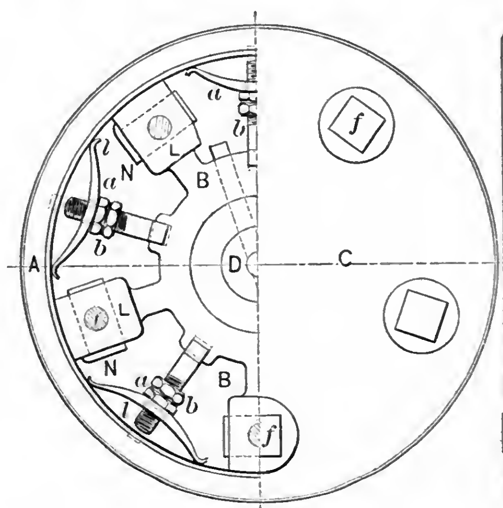


Fig. 182.

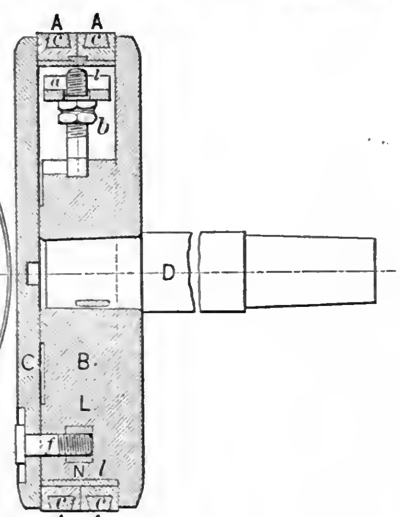


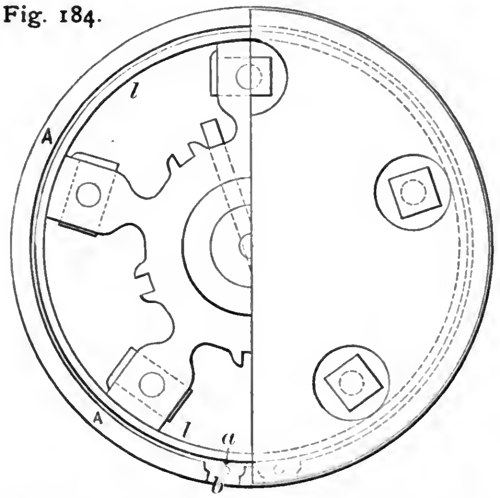
Fig. 183.

them out against the inner surface of the cylinder, and thus keep the piston tight.

QUESTION 311. *How is the piston-rod made to work steam-tight through the cylinder-head?*

Answer. By what is called a *stuffing-box*, shown at *r*, fig. 177, and on a larger scale in fig. 187. It consists of a cylindrical chamber, *r r*, which is made about 1½ in. larger in diameter than the piston-rod, which leaves a space ¾ in. wide all around

Fig. 184.



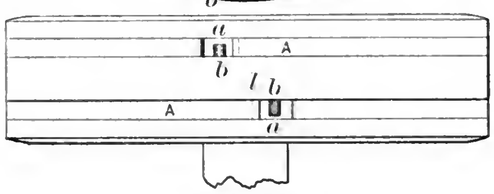


Fig. 186.

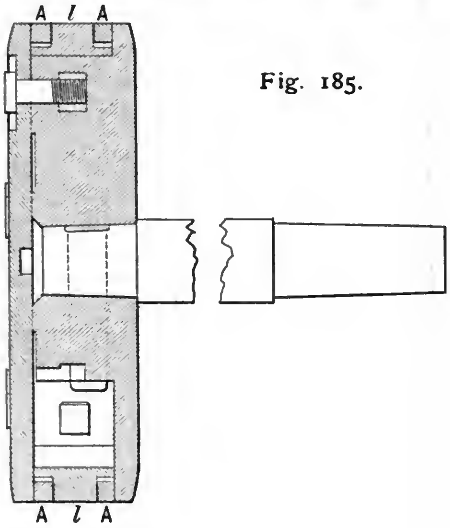


Fig. 185.

of 3 3; 4 4 has a conical cavity on the inside which contains a number of soft metal rings, 5 6 6, which are cut into a number of pieces or sectors. A solid brass ring, 7 7, bears on these, and is pressed against them by a spiral spring, 8. The steam in the cylinder also presses on these rings and forces the soft metal packing rings into the conical cavity in ring 4, which causes them to contract and bear against the piston-rod, and thus makes them steam-tight. The spiral spring holds the rings

the rod. This space is filled with hemp or some other fibrous material, called *packing*, saturated with oil or melted tallow. In some cases metal packing is used. The fibrous packing is compressed by a hollow cylinder, *t t*, called a *gland*, the inside of which fits the piston-rod *P* and the outside the stuffing-box. This gland is forced into the stuffing-box by nuts, *n n*, which are screwed down on a flange, *u u*, attached to the gland. The packing is thus compressed in the stuffing-box and forced against the piston-rod, which is made smooth and perfectly round and straight, and against the side of the stuffing-box, so that no steam can escape around the piston-rod. A brass ring or "*bushing*," *b b*, is often put into the cylinder-head, and another, *c c*, in the gland where it touches the piston-rod, because brass will resist the friction of the rod better than cast iron,

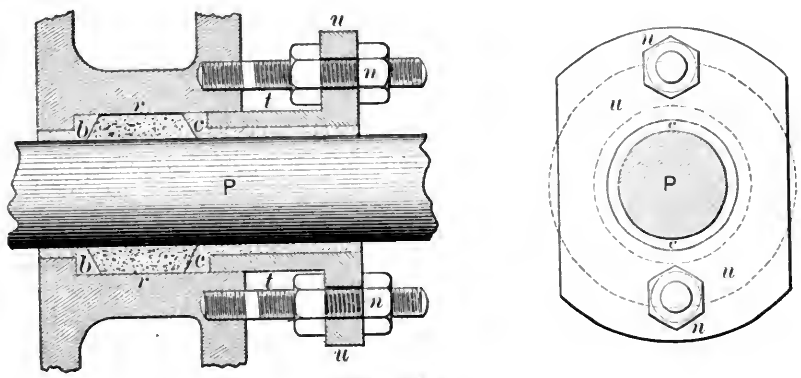


Fig. 187.

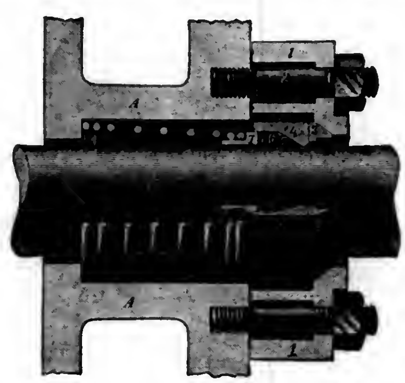


Fig. 188.

and when the "bushing" is worn out it can be removed and a new one put in its place.

QUESTION 312. *How is metal packing for piston rods and valve stems made?*

Answer. A number of different kinds of metal packing are now used. One of these kinds, made by the United States Metallic Packing Company, of Philadelphia, is illustrated by fig. 188. It consists of a cap, 1 1, which is bolted over the stuffing-box. The latter contains a number of metal rings, in which the piston-rod *B* works. These rings are made as follows: 3 3 is a solid ring made of brass, with a spherical surface on one side which bears against the cap 1 1, and a flat surface on the other side. A solid cast-iron ring, 4 4, bears against the flat surface

in place on the return stroke of the piston, when the steam in the back end of the cylinder is exhausted or when steam is shut off from the cylinders. The purpose of the spherical and flat surfaces of the ring 3 is to permit it to adjust itself to any position of the piston-rod in case it should "get out of line."

QUESTION 313. *Why is the end of the piston-rod made to work in guides?*

Answer. Because, as was explained in answer to questions 74, 75, and 76, it must move in a straight line if it and the piston work steam-tight in the cylinder. By referring back to fig. A, Plate 1 (number for November, 1887), it is obvious that if a pressure be exerted against the piston *B* and communicated to the crank-pin *N* by the connecting-rod *E*, the latter, excepting at the dead-points, will exert a pressure either upward or downward, according to the direction the piston is moving. This pressure would bend the piston-rod if no provision were made to prevent it. For this reason the end of the piston-rod is attached to what is called a *cross-head*, *M*, figs. 177, 178, and 181, which works in guides, *N N*, *N' N'*, called *guide-bars*.

QUESTION 314. *What are the different forms of cross-heads and guides that are used?*

Answer. The cross-head shown in figs. 177, 178, and 181 is the one which is generally used on passenger engines. The cross-head is made of cast iron, and has slides, *m m*, fig. 181, one on each side, which work between pairs of guide-bars, *N N'*, shown in section in fig. 181. These guide-bars are planed and finished with great accuracy, so as to be straight and smooth,

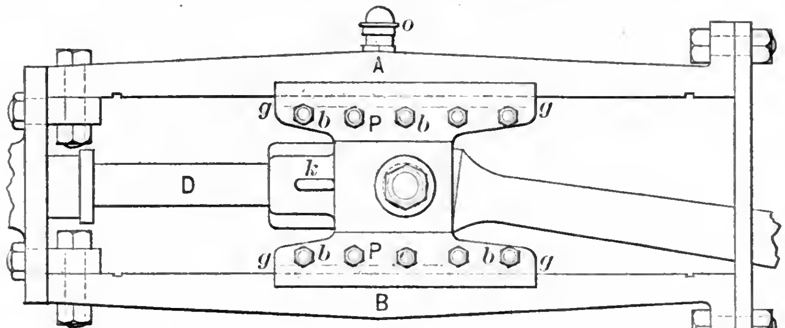


Fig. 189.

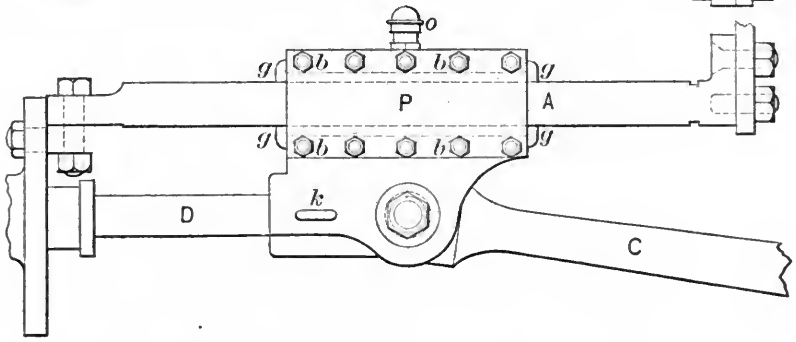


Fig. 190.

and are attached to the back cylinder-head and to a support *O*, fig. 177, called the *guide-yoke*, which is fastened to the frame at *F*, fig. 178, and is also usually attached to the boiler. The guides are set with great care, so as to be exactly parallel with the axis or center line of the cylinder, so that the cross-head will slide in exactly the same path that the piston-rod will if it moves in a straight line. If, then, the piston-rod and the connecting-rod are attached to the cross-head all the strain produced by the obliquity of the connecting-rod will be borne by the guides, thus relieving the piston-rod, and making it certain that it will move in a straight line.

Figs. 189 and 190 represent cross-heads which are used on freight engines. In fig. 189 there is a single guide-bar above and another below the cross-head. In fig. 190 there is a single guide-bar above the cross-head ; sometimes two bars above the cross-head are used instead of the single bar. These forms are used when one of the driving-wheels is opposite to the guide-bars, as is the case on mogul, consolidation, and some other engines. In such cases there is not room enough to place the guide-bars on each side of the cross-head.

QUESTION 315. *How are the piston and connecting-rods attached to the cross-head?*

Answer. The end of the piston-rod fits into a tapered hole in the cross-head and is held by a key, *w*, figs. 177 and 178, and *k k*, figs. 189 and 190. The connecting-rod is attached to a pin, *Q*, figs. 177 and 178, called a *wrist-pin*, which is cast with the cross-head.

QUESTION 316. *How is the wear of the slides lessened and compensated?*

Answer. Sometimes they are made with brass wearing pieces called *gibs*, shown at *m m*, fig. 181, which are placed between the slides and the guides. These gibs can either be removed and new ones substituted when they become very much worn, or by inserting thin pieces of metal, called liners, between them and the cross-head, they will be spread apart so as to fill the space between the slides. The slides are now, however, often made without gibs, and have recesses either cast or drilled in them, which are filled with Babbitt's metal. Double guide-bars are bolted at each end to blocks, *x x*, fig. 177, called *guide-blocks*, which can be planed off so as to bring the guides nearer together when they and the slides are worn. Sometimes liners are placed between the blocks and the guides, which can be removed when it is necessary to bring the guides nearer together.

QUESTION 317. *Are the guides worn alike?*

Answer. No ; when the engine is running forward the connecting-rod presses the guide upward during both the forward and the backward stroke of the piston, and in running backward the pressure of the rod is downward.

This will be understood by referring back to the series of figures from 15 to 28 (November, 1887). It will be noticed that in the backward stroke of the piston, represented by figs. 15 to 21, the strain on the connecting-rod tends to *push* the cross-head upward, and in the forward part of the stroke, figs. 22 to 28, the connecting-rod *pulls* the cross-head in the same direction. If the crank turned the opposite way, this action would be reversed and the cross-head would then be alternately pushed and pulled downward. Consequently, when the engine is running forward the under surfaces of the guide-bars and in running backward the upper surfaces will be worn most. As nearly all locomotives run forward more than backward, the under surfaces are usually worn the most.

QUESTION 318. *How are the slides oiled?*

Answer. Oil cups, 3 3, are attached either to the top guides, as shown in figs. 177, 178, and 189, or to the cross-head, as in fig. 190. These cups usually have a reservoir to hold a supply of oil, and are so constructed that it will be gradually fed on the slides, which are thus constantly and regularly lubricated. Their construction will be explained in another chapter.

QUESTION 319. *How are the pumps worked by the pistons?*

Answer. The pump-plunger, 4, is attached to a projection, *W*, figs. 178 and 181, called the *pump-lug*, cast on one of the slides of the cross-head. The plunger thus receives a reciprocating motion from the piston.

QUESTION 320. *What are the connecting-rods for?*

Answer. The rods which connect the cross-heads to the main crank-pins—which are called *main connecting-rods*—communicate the pressure on the piston to the main crank-pin. The rods which connect or couple the crank-pins on adjoining driving-wheels together are called *coupling-rods*,* and they cause the wheels to revolve together.

QUESTION 321. *To what strains are the connecting-rods subjected?*

Answer. They are alternately subjected to a strain of tension and compression by the pressure of the steam on the pistons during their forward and backward strokes. They must also resist the centrifugal force due to their revolution, which produces a bending action on the rods.

QUESTION 322. *How are the connecting-rods made?*

Answer. They are made of flat bars of wrought iron. Fig. 191 represents a side view and a plan of a main connecting-rod. It is attached to the wrist-pin at *A* and to the crank-pin at *B*. Fig. 192 represents similar views of a coupling-rod. To save room in the engraving each of these rods is represented with a part of the middle broken away, and a transverse section of the middle of the rod is shown between the broken ends. The main rods are usually made wider at *G*, next the crank-pin, than at the other end, as it has been found that they are most liable to break next to the *big end B*, as it is called, than at any other place. The coupling-rods are now made either straight or somewhat wider in the center. To give them greater strength without increasing their weight too much, the sections of such rods are often made "*fluted*," as it is called—that is, of the form of the letter I.

QUESTION 323. *How are these rods prevented from getting loose on the pins from the wear of the latter in the inside of the holes of the rods?*

Answer. By a stub-end or strap-end similar to that described in answer to question 77. The ends of the rods are provided

* They are also often called *side* or *parallel-rods*, but the term *coupling-rods* is considered the best.

with what are called *brass-bearings*, or "*brasses*," *c d* and *e f*, fig. 191. These brasses are made in pairs, so as to embrace the pins from each side. They are held by U-shaped clamps, *s s s*, called *straps*, which are bolted to the rods. When the brass bearings become worn, they are taken out of the straps, and a portion of their surfaces of contact with each other is filed away, thus allowing them to come nearer together, and thereby reducing the size of the hole which receives the pin or journal. In order to prevent their being loose in the straps, tapered or wedge-shaped *keys*, *k k*, are fitted in the straps and rods. By driving down these keys the straps are drawn against the brass bearings and they are forced together, thus reducing the size of the hole for the journal, and making the rods fit tightly on the pins. A hard steel plate, *p*, fig. 191, is sometimes interposed between the keys and the brasses to prevent the key from indenting the surface of the soft brass. As the keys are very liable to get loose and fall out, they are held either by screws and nuts, *x x*, as shown on the left-hand side of the engraving, or, as shown at the other end of the rod, by a *set-screw*, *r*, on the side of the rod. The ends of coupling-rods sometimes have stub-ends, as shown in fig. 192, but are often made without, and with simple *bushings* or brass rings, *b b*, driven into holes in the ends, as shown in fig. 193. When these bushings become worn they are taken out and new ones are put in their places.

QUESTION 324. *How are the journals of the crank-pins oiled?*

Answer. By oil-cups, *o o*, figs. 191 and 193, attached to the straps above the journals, similar to the cups used on the *guide-rods*. Sometimes *oil-cellars*, as they are called, are attached to the under side of the straps. These are metal boxes, which are filled with oil, which is agitated violently by the rapid motion of the rods, and is thus applied to the journals through holes drilled in the straps. In order to confine the oil and prevent its leaking out around the journals of the coupling-rods, the brasses are sometimes made so as to enclose the outside end of the crank-pin, which thus not only keeps the oil in, but excludes the dust. The brasses are usually lined with Babbitt's or some other kind of soft metal, which is thought to be less liable to heat from the friction of the journals.

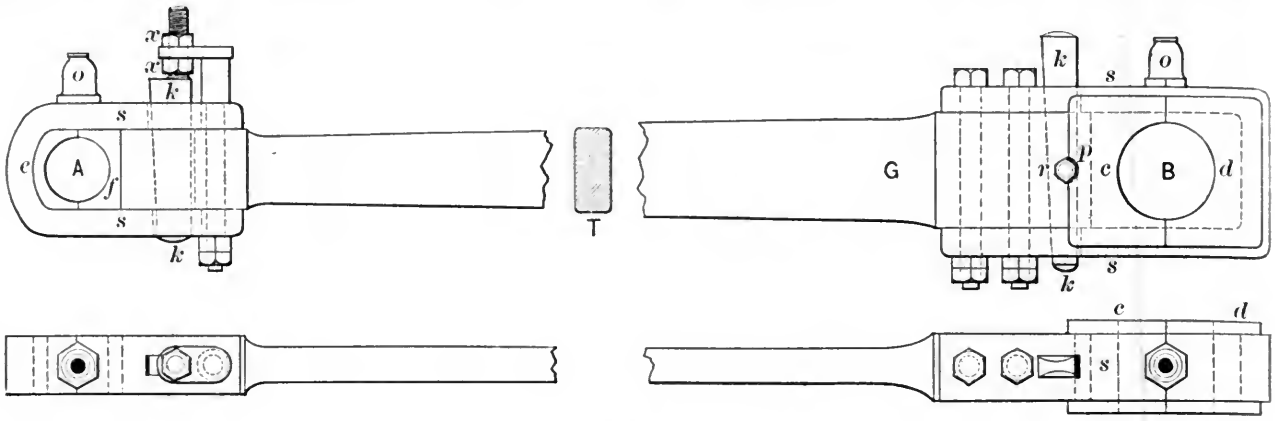


Fig. 191.

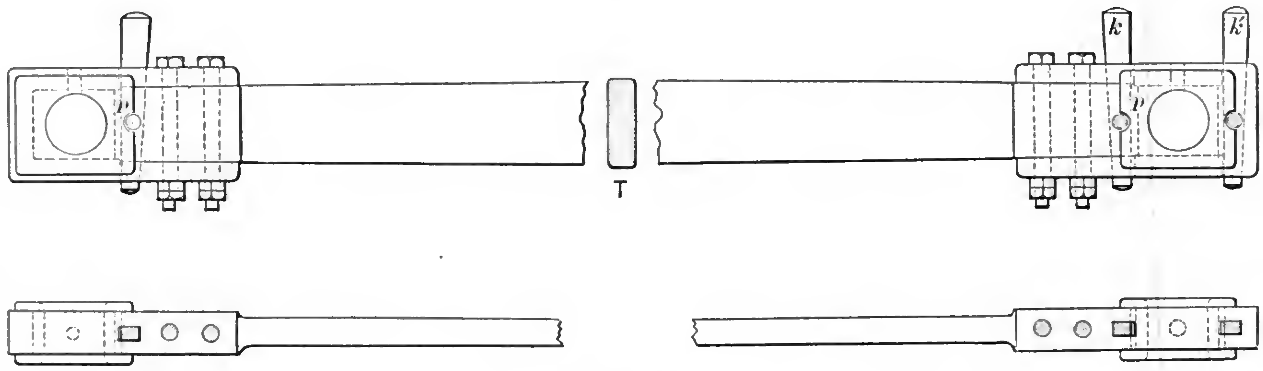


Fig. 192.

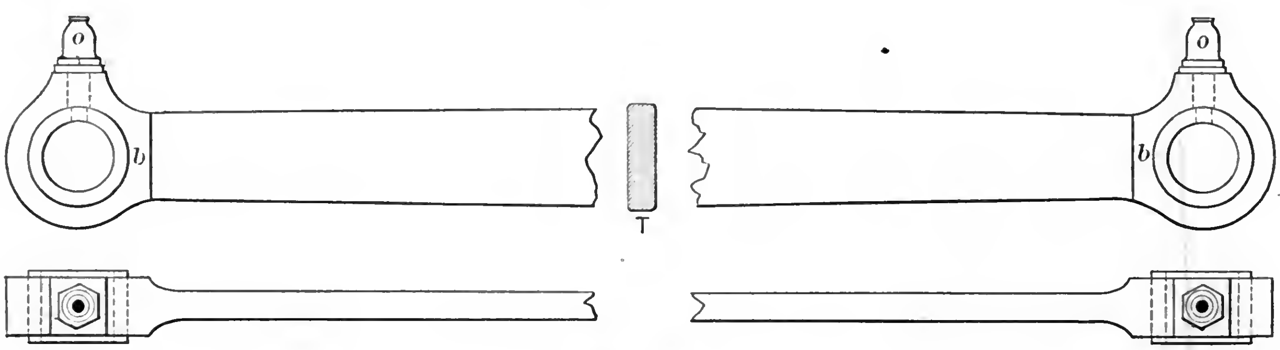


Fig. 193.

QUESTION 325. *What is meant by the term lost motion?*

Answer. It is used to designate the wear of machinery, which causes a loss of motion in some of the parts. Thus if the bearings of the main connecting-rods are worn, the piston must move a distance equal to the wear at each end of the stroke before it moves the crank-pin. Lost motion might therefore be called the looseness of the parts. When we speak of *taking up* the lost motion, we mean making parts which were loose fit tightly.

CHAPTER XIII.

THE VALVE-GEAR.

QUESTION 326. *What is meant by the valve-gear of a locomotive?*

Answer. By the valve-gear is meant the arrangement of eccentrics, rods, links, rockers, etc., by which the valves are moved and their motion regulated.

QUESTION 327. *What is required of the valve-gear in working a locomotive?*

Answer. It must be so arranged that the locomotive can be run either backward or forward, and so that the motion of the wheels can be reversed quickly and with certainty. It should enable the runner to employ the greatest power of the engine by admitting steam into the cylinders during the whole or nearly the whole of the stroke of the pistons, or, when less power is required, to use the steam more economically by working it expansively.

QUESTION 328. *How is the valve-gear constructed so as to run the engine either backward or forward?*

evident in that case that the valve must be moved in the same direction as before, to open the front steam-port *c*, and thus admit steam to force the piston back. But if the crank turns in the direction shown by the dart *N*, fig. 195, then the center of the eccentric *K* must be placed *below* the center of the axle to move the lower rocker arm in the direction of the dart *b*, and the valve in that indicated by *a*. It will thus be seen that the center of the eccentric for running forward and of that of the one for running backward must be placed, the one above and the other below the center of the axle at the beginning of the stroke of the piston, as shown in fig. 101.

QUESTION 330. *Why is it that the centers of the eccentrics are not placed opposite to each other on the axle?*

Answer. Because before the beginning of the stroke of the piston it is necessary to move the valve from its middle position a distance equal to the lap before the steam-port begins to open. If we had a valve without any lap, the centers of the eccentrics could be placed at right angles, or, as mechanics say, "square" with the crank, and exactly opposite to each other, because such a valve would begin to take steam as soon as it moved from the middle of the valve-face. But if we have a

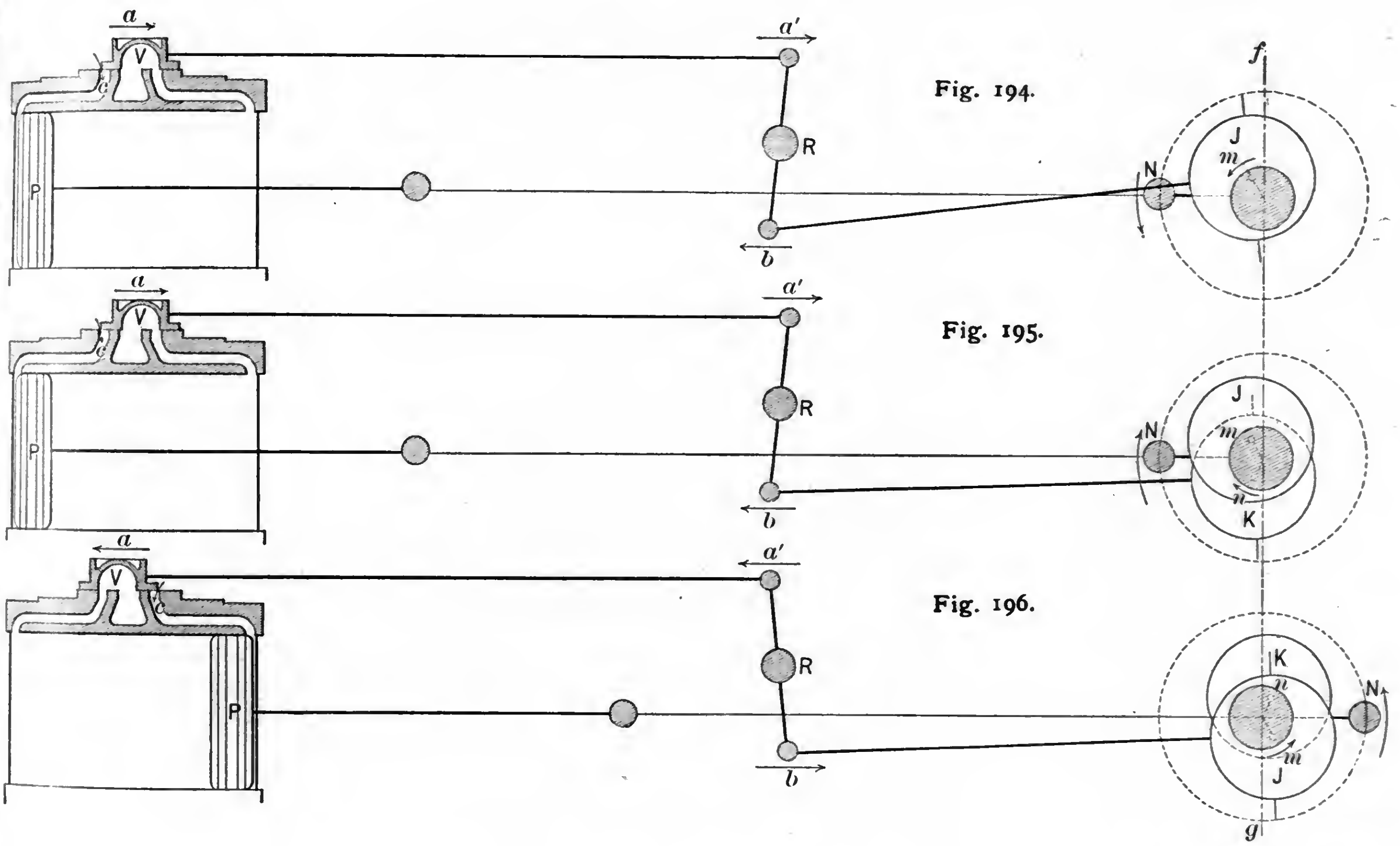


Fig. 194.

Fig. 195.

Fig. 196.

Answer. As already explained, in answer to question 287, two eccentrics are provided for each cylinder. These are set so that one of each pair will run the locomotive in one direction, and the other two the reverse way.

QUESTION 329. *How must the eccentrics for each cylinder be set in order that the one may run the engine forward and the other backward?*

Answer. This can be best explained by reference to fig. 194, in which the piston, *P*, is represented at the beginning of the backward stroke, and the valve *V* has the requisite lead, and is just about to open the front steam-port. It is obvious that, in order to complete the backward stroke of the piston, the front port, *c*, must be opened to admit steam into the front end of the cylinder, and therefore the valve must be moved in the direction indicated by the dart *a*. To do this, the upper arm of the rocker *R* must move in the same direction indicated by the dart *a* and the lower arm must be moved the reverse way, as indicated by the dart *b*. If the crank is intended to move in the direction indicated by the dart *N*, then the center of the eccentric *J* must be above the center of the shaft or axle, to move the lower end of the rocker in the direction indicated by the dart *b*. Supposing, however, it was intended to move the crank the reverse direction, as shown by the dart *N* in fig. 195; it is

valve like that shown in fig. 49, it is plain that before it will admit or *take* steam, as it is called, in either of the steam-ports, it must be moved from the center of the valve-face, or its *middle position*, a distance equal to the lap, *L*. For this reason, therefore, the eccentric, instead of being placed at *half-throw*,* as it is called, must be so far ahead of the middle position as to have moved the valve a distance equal to the lap, and if any lead is given to the valve, equal to the lap and lead together. In figs. 194, 195, and 196, *fg* is a vertical line at right angles to the crank at the beginning of the stroke. It will be seen that the center of each of the eccentrics is set far enough ahead of this line to give the valve the required lead. When the piston reaches the back end of the cylinder, the two eccentrics will occupy the position shown in fig. 196, in which position the lower one, *J*, would move the valve so as to turn the crank in the direction of the dart *N*, and the upper one, *K*, will turn it in the reverse direction. It will be seen that in this position both of the eccentrics are again ahead of their half-throw, when the piston is at that end of its stroke.

(TO BE CONTINUED.)

* This would be at right angles to the crank when it is at a dead point, and the piston is at the end of the stroke.

Manufactures.

The Baker Dust-Guard.

THE accompanying illustrations represent a dust-guard intended to prevent the entrance of dust and sand into car journal boxes; and also to prevent the leakage of oil from them. This system, it is claimed, avoids the defects of some others which have been previously devised, and has proved in service very effective in reducing the wear of journals and bearings, and also in saving the amount of lubricating oil used. The accompanying illustrations, figs. 1 and 2, show the device as applied to a M. C. B. standard axle-box, with the addition of a lubricating device and dust-tight lid in connection with the dust-guard itself.

The system adopted in this arrangement is that of a cushioned and spring-actuated washer revolving with the axle and wheel and bearing on the back of the axle-box, which is made smooth to receive it. Around that part known as the dust collar of the axle of any ordinary construction is a metallic sleeve formed with a key-way, or longitudinal groove, on its inner side, which fits over a key in the axle, so that while the sleeve is keyed to the axle and revolves with it, it is free to move longitudinally. The key is T-shaped and is inserted in a $\frac{5}{8}$-in. hole drilled $\frac{1}{2}$ in. deep in the axle at the proper place. A coiled spring, bearing at one end against the flange and at the other against the face of the hub of the car-wheel, is placed on the outside of the sleeve. It has a flange at the end next to the axle-box. Upon the face of the flange next to the axle-box is riveted a vulcanized asbestos washer, which bears against the axle-box, making a dust-tight joint. The spring is made just strong enough to hold the flange and washer up against the axle-box without undue pressure or friction, and to permit the usual amount of end-play of the journal without uncovering the opening in the box. Experience has shown that the wear upon the washers is extremely light.

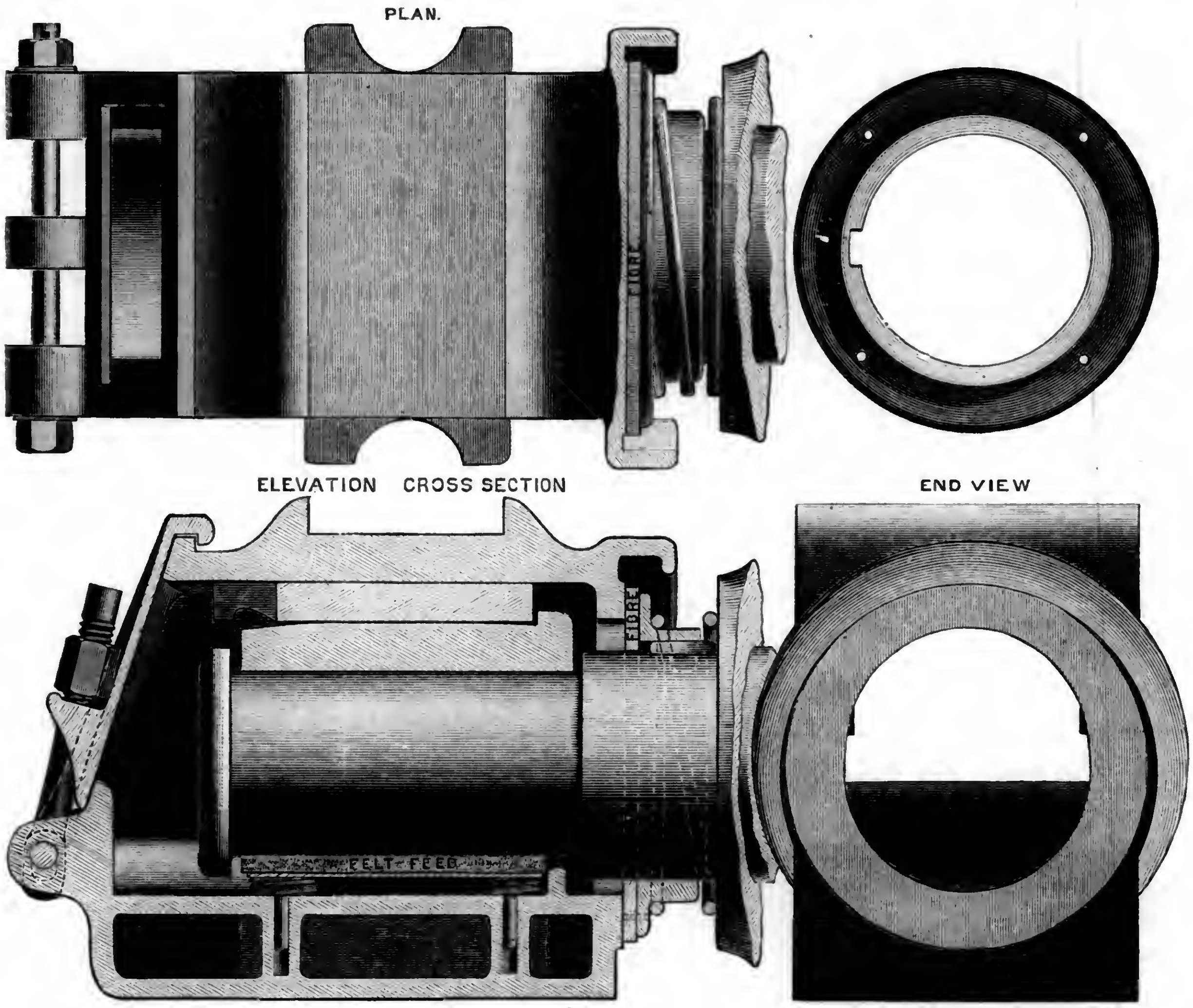


Fig. 1.
THE BAKER DUST-GUARD.

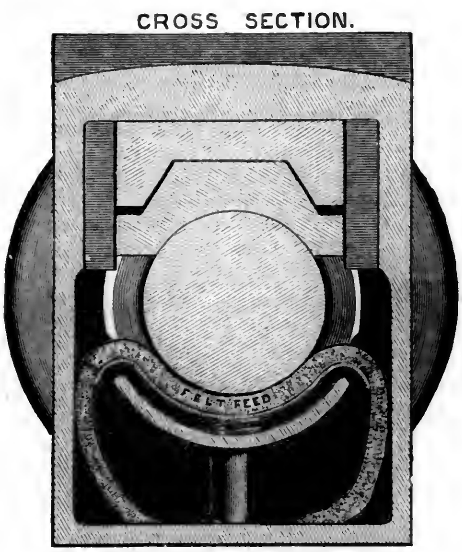


Fig. 2.

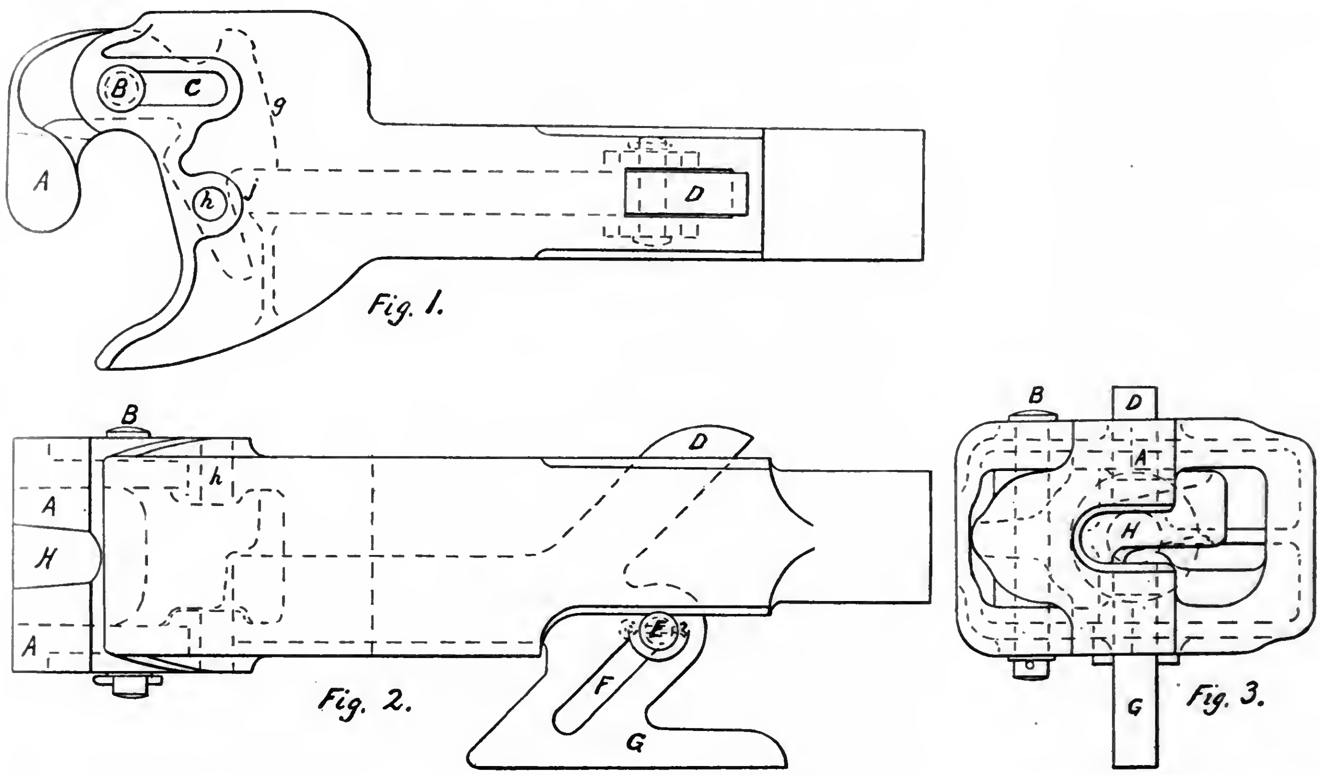
This dust-guard can be applied to any pattern of axles or axle-boxes in use, the only change required being that the back of the box should be left smooth by leaving off the dust-guard housing ordinarily cast on the box. The use of the dust-guard will not prevent interchange with the present pattern of boxes should occasion for it arise.

The inventor and manufacturer, Mr. W. S. G. Baker, of Baltimore, claims that the use of his dust-guards reduces considerably both the quantity of oil used and the wear of the bearings. Their cost is very small both in itself and in comparison with the saving effected by their use. They have been in service long enough to fully test their merits.

The Hix Car-Coupler.

It was predicted a month or two ago in these pages that the adoption by the Master Car-Builders' Association of standard contour lines for automatic couplers would result in a new crop of inventions "that will couple to and with" couplers having these contour lines. An invention of this kind is shown by the engravings herewith.

One of the difficulties with the Master Car-Builders' type of coupler is that the hook, *A*, must resist the concussion when a car equipped with such a coupler comes in contact with one having the old-fashioned draw-bar. The consequence is that the hooks are sometimes broken by the concussions. The inventor of the coupler illustrated has tried to overcome this difficulty by attaching the hook *A* to the draw-head by a slot *C*, in which the pin *B* can slide; consequently, when an ordinary draw-bar comes in contact with the hook it is simply pushed back until it bears against the draw-head, thus relieving the pin *B* of all strain on it. *G* is a latch connected to the draw-head



THE HIX CAR-COUPLER.

by a pin *E* and slot *F*, fig. 2. When the hook is pushed back in buffing it moves the latch *G* upward on the bolt *E*, so that when the pressure on the latch is relieved its weight causes it to fall downward, and thus pushes out the hook into the position shown in the engraving. Ordinary draw-bars are coupled by a link to a pin *h*, which is in the head instead of being attached to the hook, as in the Janney and some other forms of couplers. The knuckle-joint of the hook is thus relieved of all strain of pulling and buffing when coupled to ordinary draw-bars.

This coupler is the invention of O. P. Hix, of Rockland, Me.

Air Compressors.

The use of compressed air in operating rock drills and other machinery in tunneling and other underground work has become so general that the air compressor is recognized as an essential part of the contractor's plant. It is equally so in putting in the substructure of bridges, the employment of the pneumatic process being almost universal wherever it can be used.

In the Stampede Pass Tunnel on the Northern Pacific Railroad, the completion of which is noted elsewhere, much of the work was done by a Clayton air compressor operated by water power. Compressors of the same make were used in sinking the caissons for the piers of the Bismarck bridge on the Northern Pacific road, and have been employed in many other places.

The special advantages claimed for these compressors are the close regulation of the speed by which uniformity of pressure and steadiness of action are secured, and the arrangements by which the air cylinders are kept cool.

These compressors are not only used for tunnel and mining work, bridge foundations and similar work, but also in wrecking and other submarine operations, to furnish air to divers. In this class of work their steadiness and uniform action are especially valuable.

Electric Street Cars.

The Sprague motor is now on trial on the street railroad line in Davenport, Ia. The cars of that line are already lighted on the Sprague system.

A street car operated by storage batteries on the Julien system is now on trial on the North Baltimore Passenger Railroad. There are many heavy grades on this line which it is stated the car works over without difficulty.

During June the upper section of the Fourth Avenue line in New York, running from the stables on 86th Street to the Mott Haven station at 138th Street, will be operated entirely by electric cars. A number of these cars are completed and nearly ready to be put in use. The Julien storage batteries are used, and the car is similar to that which has been running on the Fourth Avenue road for some time.

Indurated fiber, which has recently been introduced for many purposes, has found a new use; it is now employed in the manufacture of cells for storage batteries and electrical accumulations. The cells for the new electric cars on the Fourth Avenue line are made of this material, and it has also been applied for the manufacture of pipes or conduits for underground wires.

Track Washers.

A substantial improvement has recently been made in the manufacture of fiber track washers by the Vulcanized Fiber Company. This consists in the use, in place of the iron casing in which the fiber has heretofore been held, of a casing or base of steel, stamped out of thin steel plate. This is not only stronger, but is more durable, and in every respect better than the iron washer, and it is also lighter. The use of these washers for track-bolts is approved by long use and practical service in the track.

Marine Engineering.

The steel ferry-boat *Erastus Wiman* was recently launched from the yard of the Columbian Iron Works in Baltimore. The boat is of the following dimensions: Length between perpendiculars, 225 ft.; length over all, 236 ft.; breadth of beam, moulded, 36 ft.; breadth over guards, 64 ft.; depth of hull, 14 ft.; draft of water, including keel, 7 ft. 10 in.; draft of water from base line, 7 ft.; estimated displacement, 1,100 tons. The hull is of steel of 60,000 lbs. ultimate tensile strength per square inch of section, with a ductility of not less than 23 per cent. and an elastic limit of 35,000 lbs. per square inch of section. The steel throughout is of the best quality obtainable for the purpose.

The *Wiman* will have one inclined compound engine of about 1,200 indicated H.P. The cylinders are placed side by side and act upon a shaft having two cranks at right angles with each other. They have separate sets of eccentrics for running each way. The valve of the high-pressure cylinder is a piston valve, while that of the low-pressure cylinder is the plain side valve. The high-pressure cylinder is 39 in., and the low-pressure 70 in. diameter, both having 60-in. stroke. The boat is to run between New York and Staten Island.

Cars.

The Lappin Brake Shoe Company has removed its offices from No. 239 to No. 45 Broadway, New York.

The Consolidated Coupling Company has removed its offices from No. 173 Broadway to No. 45 Broadway, New York.

The Michigan Car Company in Detroit is building 200 cars for the Wheeling & Lake Erie Railroad.

The Wells & French Company in Chicago is filling an order for 500 box cars for the Minneapolis, Sault Ste. Marie & Atlantic road.

The Peninsular Car Works in Detroit are building 1,000 box cars for the Northern Pacific Railroad, filling an order given some time ago.

The St. Louis Car Company is building 35 cars for the Indianapolis street railroad lines, and has orders to fill for several other cities.

The Laclede Car Company in St. Louis is building 60 cars for the new cable line in Kansas City. The cars are furnished complete, including grips.

The Martin Anti-Fire Car Heater Company, it is stated, has received orders to equip 25 more baggage cars and 20 more engines of the New York Central & Hudson River. The new shops at Dunkirk will be occupied soon.

The Pennsylvania Company is equipping 200 stock cars with Janney couplers and Westinghouse air brakes at the Fort Wayne shops. These cars are to run on through stock trains from Chicago.

The Wason Car Works at Springfield, Mass., are building a palace car for the use of Dom Luis I., King of Portugal. It is to cost about $18,000, and to be of the best materials. The outside of the car will be highly finished, and the color will probably be white; the interior wood work will be of mahogany of two or three varieties, and the wood will be handsomely carved. The car will be divided like the ordinary buffet palace car used in this country, excepting that at one end of the drawing-room, a tier of berths will be put in, which will not mar the beauty of the interior when not in use, and which may be divided off when required so that a good-sized state-room will be secured.

Manufacturing Notes.

The Rogers Locomotive Works in Paterson, N. J., recently delivered four Mogul freight engines to the Georgia Pacific Railroad.

The Baldwin Locomotive Works in Philadelphia recently delivered 20 consolidation freight engines to the East Tennessee, Virginia & Georgia Railroad, and have received orders for 15 more consolidation and 10 passenger engines for the same road.

The Boston Heating Company recently purchased 45 Curtis pressure regulators from ½ in. to 3 in. in size. The larger ones are used to control the pressure on the pumps at the central station; the small ones to reduce the 400 lbs. pressure on the street mains to from 5 to 80 lbs. as required for heating and power purposes.

The Johnson Steel Street Rail Company has just completed an entirely new plant at Johnstown, Pa., which was successfully put in motion for the first time on May 7. The plant embraces a two-high 26-in. roll train and five heating furnaces, of the Gadsden regenerative type, each with 15-ft. beds. Bessemer blooms, purchased in the open market, will be rolled into any form of street rails that may be desired. The works are supplied with a powerful engine, traveling cranes, and all the other appliances of a first-class rolling mill. The total length of the building covering the mill is 450 ft., all fire-proof. The capacity of the works is from 100,000 to 150,000 tons per annum.

The National Tube Works Company now has eight large building furnaces running in its works at McKeesport, Pa., making the output over 600 tons per day.

The following changes have been made in the officers of the Safety Car Heating & Lighting Company, New York: President, Henry R. Towne; Vice-President, James C. Bayles; Secretary and Treasurer, J. J. Slocum. F. M. Wilder has resigned as General Manager, and his duties have been assumed by the Vice-President.

The Harris-Corliss Engine Works, heretofore conducted under the name of William A. Harris, have, by act of the General Assembly of the State of Rhode Island, been incorporated and are now styled the William A. Harris Steam Engine Company. Mr. Harris, who established this business in 1864, is President and Treasurer of the new company, and the works will be conducted and managed in the same manner as when run in his own name.

The Betts Machine Company in Wilmington, Del., is making what is probably the largest and heaviest engine lathe ever made in this country. It is triple back geared, all the gears being cut out of steel. The screw is 4½ in. in diameter. The bed, which is some 8 ft. wide, is 35 ft. long, and the face-plate is 66 in. It will weigh, complete, 120,000 lbs. It is being made for the Midvale Steel Company. This company is also erecting a planer for the Penn Diamond Drill Company, which has an 8-ft. opening, and will plane 25 ft., the bed being 40 ft. long. It carries four tools, two on the cross-head and one each on the uprights. It will weigh 90,000 lbs., complete.

In Cleveland, O., May 8, in the foundry of the Walker Manufacturing Company, there was cast a gear-wheel weighing 50,000 lbs. This is probably the heaviest wheel ever made in this country; it is to be the main driving wheel for the new plant of the St. Louis Cable Railroad.

The Chester Foundry & Machine Company, of Chester, Pa., has secured the exclusive right to manufacture the well-known three-cylinder Brotherhood engines for the United States, and has fitted up one of the departments with special tools for this work.

The Passaic Rolling Mill Company in Paterson, N. J., is building a new iron bridge over the Peedee River on the Wilmington, Columbia & Augusta Railroad.

Riehle Brothers, in Philadelphia, report a more active demand than for some time past. Orders have recently been received for two 30-ton platform scales for Cramp & Sons' shipyards, and four for the Phœnix Iron Company, besides a number of heavy rolling-mill, furnace, track, and mine scales. They have also orders for a 5,000-lbs. testing machine for the Edison Machine Works at Schenectady, N. Y., and for other testing machines for different parties, besides orders for other machinery.

The Southern Pacific Company is building some large additions to the shops at Sacramento, Cal. These include additions 150 by 90 ft. to the boiler shops; 100 by 112 ft. to the machine shop; 90 by 92 ft. to the car shop; 85 by 180 ft. to the paint shop; a two-story shop for car work, 75 by 150 ft. in size, and an oil house 50 by 100 ft. All the shops are to be fitted up with electric lights.

The Keystone Bridge Company in Pittsburgh has the contract for 10 iron spans of 150 ft. each over the Sandusky River at Fremont, O., on the Lake Erie & Western road.

The Rhode Island Locomotive Works in Providence have recently received a number of orders for locomotives, chiefly from Western and Southern roads. These orders include 10 consolidation engines for the Louisville & Nashville road; three 10-wheel engines for the Southern Pacific; several 10-wheel engines for the Cincinnati, Milwaukee & St. Paul; five consolidation freight engines for the Seattle, Lake Shore & Eastern road; three Mogul freight engines and three Forney engines for the Minneapolis, St. Paul & Atlantic; several switching engines for the Cincinnati, New Orleans & Texas Pacific; and a Forney engine to go to Bessemer, Ala., for the De Bardaleben Coal & Iron Company.

A New Car Spring.

From the time when railroad cars first came into use there has been a continued effort to secure some method by which the shocks resulting from the rapid motion and the inequalities of the track can be taken up, and an easy-riding car provided. Of course the method employed from the first has been to interpose springs of some kind between the running gear—the wheels and axles which bear directly on the track—and the body of the car. The improvements made heretofore have been, not in the general principle, but in the construction and arrangement of the springs. A great variety of these have been devised and put into use with more or less success.

The last candidate for the favor of the railroad public is the Chase combination spring. This spring is a combination of a double elliptic spring having a coiled spring placed across the center, and held by bolts passing through the ends of the elliptic. In this way the supporting power of the coiled spring is brought into use gradually, as the pressure on the entire spring increases, and the resistance of the spring adjusts itself, as it were, to the demands upon it.

It is claimed for this spring that it is much lighter than any other now in use, a set of passenger springs weighing over 30 per cent. less than the ordinary spring.

A second claim is that, on account of the support given to the end of the elliptic by the spiral, the danger of breakage is very much lessened.

A third advantage claimed is that, for the same reason, the motion of the spring is much easier and more gradual, and there is none of the quick, jerky motion, or the sudden shocks sometimes felt with the ordinary spring.

It is stated that where this spring was in use under a passenger car, no difference could be felt in the riding of the car when empty or when filled with passengers. As to durability, the most extended test yet made has been with a set of freight springs, which have been running for six years (and which weigh much less than a set of the ordinary springs), and are still in use.

Proceedings of Societies.

American Society of Civil Engineers.

April 18, the subject was the Manufacture of Brick. A written discussion from Mr. Parrington was read, and the subject was verbally discussed by Messrs. Church, Cartright, Tomkins, and Fteley.

A regular meeting was held in New York, May 2. It was announced that Sullivan Haslett, late a member, had bequeathed his engineering library to the Society.

The Secretary stated that the last week in June had been selected as the date of the annual convention, and that the excursion would be over the Michigan Central Railroad, from Buffalo to Milwaukee.

Members intending to present papers at this meeting are urgently requested by the Committee to prepare them early enough to enable advance copies to be printed and distributed among the members for preparation of discussions.

The Secretary read a rejoinder from John W. Hill to Mr. Howell's discussion of the former's recent paper on Test of an Edison Incandescent Electric-Lighting Plant, and extracts from a communication by Joseph Nimmo, Jr., on Fertilizing Material of New York and Brooklyn in its Relation to Transportation.

The following candidates were declared elected :

Members : Kenneth Allen, Kansas City, Mo.; Latham Anderson, Cincinnati, O.; Thomas Aspinwall, Boston, Mass.; Robert Bassel, Washington, D. C.; Harry Dean Bush, Montreal, Can.; Clarence Allen Carpenter, Chillicothe, Mo.; George Edwin Evans, Helena, Mont.; Francis Davis Fisher, New York City; Arthur Hodges, Johnstown, Pa.; George Washington Howell, Morristown, N. J.; Everett Wilson Lewis, Belmont, Wash. T.; Emile Low, Cedar Bluff, Va.; Harry Irving Miller, Richmond, Ind.; Arthur Lorenzo Mills, Toledo, O.; Edmund Trowbridge Dana Myers, Richmond, Va.; Philip M. Price, West Point, N. Y.; Beverley Strother Randolph, Frostburg, Md.; Thomas Pearman Shanks, Louisville, Ky.; George Morris Tompson, Boston, Mass.; Thomas Delano Whistler, New York City.

Associate : James Breckenridge Speed, Louisville, Ky.

Juniors : James Hillhouse Fuertes, Wichita, Kan.; William Gray, Tarrytown, N. Y.; Horace Joseph Howet, Elmira, N. Y.; Edmund Trowbridge Dana Myers, Jr., Richmond, Va.; John Edwin Ostrander, Macedon, N. Y.; Charles Bradley Rowland, Greenpoint, N. Y.; Eugene Raymond Smith, Islip, N. Y.; William Holland Stair, Fort Riley, Kan.; George Atwater Tibbals, Brooklyn, N. Y.; Samuel Gaylord Tibbals, Brooklyn, N. Y.; Herbert Waldo York, New York City.

A regular meeting was held at the Society's house in New York, May 16. The death of Henry F. Welling, a member, was announced, and a committee was appointed to prepare the usual memoir.

James B. Francis, Past President of the Society, read a paper on High Walls or Dams to Resist the Pressure of Water, in which he investigated the conditions of stability of a dam under differing circumstances. The paper was discussed by a number of members present, and further discussion will be had at the next meeting at the Annual Convention. Mr. Francis's high standing as hydraulic engineer gives his paper special importance.

Boston Society of Civil Engineers.

A regular meeting was held at the rooms, Boston & Albany Railroad Station, Boston, April 18 ; 43 members and 14 visitors present.

President Desmond Fitzgerald, on assuming the chair, thanked the members of the Society for the honor conferred on him in selecting him to preside over the Society for the coming year, and briefly sketched the programme which had been laid out for the meetings for the ensuing year.

The following were elected to membership : Fred. H. Barnes, Newton, Mass.; Nathan S. Brock, Lowell, Mass. ; William H. Chapman, Newport, R. I.; Louis Cutter, Winchester, Mass.; William C. Hall, South Framingham, Mass.; Frank L. Locke, Arthur G. Robbins, Boston, Mass.; George E. Whitney, Cambridge, Mass.; J. L. Woodfall, Chelsea, Mass.; E. E. Young, Hyde Park, Mass.

Committees for the ensuing year were announced by the Secretary and an amendment to the by-laws considered.

Mr. L. Frederick Rice, Chairman of the commission appointed by the city of Boston to test meters, then read a paper entitled, Method and Apparatus Used in the Recent Test of Water Meters at Boston.

Portions of the apparatus used at the test were exhibited and fully explained.

Mr. Edmund B. Weston, of Providence, followed with a paper on the Water Meter System of Providence. He described the method used in that city in testing meters before they were allowed to be used, and gave very full statistics as to cost of keeping the various kinds of meters in repair.

After a general discussion of the two papers, the Society adjourned.

Engineers' Club of Philadelphia.

At the regular meeting at the Club's House in Philadelphia, April 21, the Secretary announced the gift to the Club, by Mr. John S. Naylor, Member, of *Van Nostrand's Engineering Magazine*, 1869 to 1886, both inclusive, bound in half morocco. A vote of thanks was returned to Mr. Naylor for this handsome and valuable addition to the Library.

Mr. L. F. Rondinella presented a series of Steam Formulæ for the *Reference Book*.

Mr. William Sellers, a paper upon the Manufacture of Eye Bars for Pin Connected Structures, illustrated by full-size test specimen, etc.

Mr. John L. Gill, Jr., discussed the desirability of Expanding in, and of Beading over, Boiler Tubes, and raised the point as to whether beading over was not, in some cases, unnecessary, or even injurious.

The President announced the following as the Committee to Recommend a Practical Method of Testing Cements, the appointment of which was authorized at the meeting of March 17 : Arthur Marichal, Chairman, Herbert Bamber, Professor L. M. Haupt, Rudolph Hering, and John C. Trautwine, Jr.

At the regular meeting in Philadelphia, May 5, the Secretary presented for Mr. Oscar Sanne an illustrated description of a Rolling Bridge for Docks.

Mr. Robert A. Cummings presented, for the *Reference Book*, a Table of Equality of Curves at Different Scales, by means of which a set of curve patterns cut for a certain scale can be used for other scales.

Mr. M. R. Mucklé, Jr., described a general and detailed arrangement for a system of Underground Conduits for Electrical Conductors, with numerous illustrations.

Mr. Henry G. Morris presented a number of specimens of Mitis Metal Castings, and an illustrated description of the furnace used in their manufacture.

Cincinnati Association of the American Society of Civil Engineers.

A MEETING was held in Cincinnati, April 17, at which there were present a number of members of the American Society of Civil Engineers residing in Cincinnati and vicinity. It was decided to organize an Association for the purpose of discussing questions of interest relating to the American Society, and to bring together such members as reside in the city or visit it frequently. The name of the organization will be the Cincinnati Association of the American Society of Civil Engineers, and members of all classes are eligible to admission. Colonel William E. Merrill was elected President, and G. B. Nicholson, Secretary.

Engineers' Club of St. Louis.

AT the regular meeting in St. Louis, April 18, John H. Mueller and C. W. Stagl were elected members. The Club then proceeded to consider a communication from the Council of Engineering Societies on National Public Works. After discussion the subject was referred to a committee of three to report in May. F. E. Nipher, S. B. Russel, and A. W. Hubbard were appointed the committee.

Mr. S. Bent Russel then read a paper on Thickness of Water Pipes, with some Experiments on Ram, which was illustrated by a number of charts and tables showing the results, the instruments made, and the formula deduced from them. The paper was generally discussed.

AT the regular meeting of May 2, Professor A. E. Phillips was elected a member. The Librarian reported the completion of a catalogue of the books and pamphlets owned by the Club. A communication requesting the Club to confer with other associations on the subject of improvements in highway bridges, was referred to a committee of three, consisting of H. A. Wheeler, C. H. Sharman, and M. G. Schinke. Mr. J. A. Ockerson presented his resignation as Vice-President, owing to his removal from the city.

Colonel E. D. Meier read a paper on the Prall System of Distributing Heat and Power from a Central Station. This system provides for the use of water heated to a very high temperature and then pumped from the station through pipes. The paper called out an extended discussion.

Engineers' Club of Kansas City.

AN adjourned meeting was held in Kansas City, April 16. The President reported, in brief, the action taken by the delegates at Washington respecting the Cullom Bill, and stated that it would pass the Senate without difficulty, and would probably meet with little opposition in the House.

The discussion of Professor Waddell's pamphlet on Highway Bridges was continued by the reading of several papers, which were afterward verbally discussed by the members present.

Mr. Chanute presented resolutions, which were adopted, for the appointment of a committee to prepare a memorial to the Legislature of the State with a draft of a law providing for inspection of bridges, and that the Secretary be instructed to correspond with other engineering societies to secure co-operation in different States. For this purpose he stated that the reforms desired were to secure the employment of expert engineers; the establishment of legal standards of strength; the forming of a society of responsible bridge-builders, and State inspection of all bridges. The committee appointed under these resolutions is composed of Messrs. Chanute, Waddell, and Breithaupt.

A REGULAR meeting was held in Kansas City, May 7; the following elections were announced: Members: Daniel Bontecou, O. B. Gunn, E. J. Farnsworth, Alexander Potter, M. M. Wells, and William B. Upton. Associate members: H. F. Hill and F. C. Florence.

The Secretary read letters from B. W. DeCourcy, of Independence, Kan., describing some piers and abutments recently erected near there which had failed; also a bow-string girder which was considered unsafe. Photographs of the work were enclosed. The Secretary made some remarks about this masonry, which he had inspected, and also presented tests of the stone.

Mr. Mason gave a brief description of the pavements in use in Kansas City, and spoke especially of the Trinidad asphalt, which he claimed would be hereafter the principal paving material used, on account of its durability and the ease of drainage. Mr. Mason's paper was discussed by members present.

Western Society of Engineers.

A REGULAR meeting was held in Chicago, April 9. The memorial to Congress on the proposed new system of organizing and conducting public works was discussed and amended.

A communication was received from Mr. T. J. Nicholl, Vice-President and General Manager of the Natchez, Jackson & Columbus Railroad, accompanied by a letter from the Pennsylvania Steel Company, advocating the use of rails $33\frac{1}{3}$ ft. long as standard, as cars are now 34 ft. After an informal discussion the letters were ordered placed on file.

The Committee on Highway Bridges presented a supplementary report renewing its recommendations as to State inspection of bridges, and adding the following:

"Inasmuch as we think it desirable that any action taken shall be, as far as possible, the joint action of all organizations similar to our own, we recommend, as a step preliminary to such joint action, that the Secretary be instructed to place himself in communication with other local engineering societies, and request from them an expression of opinion on the subject under consideration."

The report was discussed at length by Messrs. Strobel, Williams, Cregier, Gottlieb, Bates, Parkhurst, and others, and finally referred back to committee, with instructions to correspond with other societies, with a view to an expression of opinion and ultimate co-operation.

The question of permanent quarters, and generally of placing the Society upon a more substantial footing, was then taken up. The feasibility of accomplishing material results was generally conceded. The trustees were requested to consider the whole question and report a definite line of action.

The reading of papers was postponed until next meeting.

Montana Society of Civil Engineers.

A MEETING was held in Helena, Mon., April 28, at which Mr. J. H. Farmer read a paper on the Location and Construction of the Wickes Tunnel.

Resolutions in favor of the Cullom Bill for reorganizing the river and harbor service were adopted, and a committee appointed to co-operate with the Council of Engineering Societies.

New England Railroad Club.

THE regular monthly meeting was held at the rooms in Boston, May 9. The first business taken up was the reading of a new constitution and by-laws as drawn up by a committee appointed for that purpose. A discussion arose on the method of dealing with members who had to be dropped owing to nonpayment of dues, and it was decided that, before such members could become eligible for future membership, they would have to pay all arrears due. The report was adopted unanimously.

A resolution was adopted endorsing and approving of the action of the President at the last meeting in summarily suppressing remarks that were improper and distinctly out of order. President Lauder, while regretting somewhat that such a resolution was brought forward, returned thanks for the endorsement which it contained.

It was decided to appropriate and pay the usual sum for the services of the Secretary and Treasurer.

The discussion on Steam Heating of Passenger Cars, brought over from the April meeting, was then taken up. The special topic was Radiating Pipes and Valves, which was discussed by Messrs. Chase, Baker, and others present.

Western Railroad Club.

THE regular monthly meeting was held in Chicago, May 16. The subject for discussion being the Proper Size of Axles for a 60,000-lbs. Car. Letters were received from Messrs. Forsyth, Sutherland, and Stevens, and the subject was discussed by Messrs. Barr, Rhodes, Sinclair, and others. At the close of the

discussion the following dimensions were agreed upon to be recommended to the Master Car-Builders' Association as a standard: Length, 6 ft. 11½ in.; between center of journals, 6 ft. 3 in.; size of journals, 8 by 4¼ in.; diameter of axle at center, 4⅜ in.; diameter at wheel seat, 5¼ in.; diameter of dust-guard bearing, 5 in.

A resolution instructing the Secretary to issue a circular urging railroad officers to attend the meetings was adopted; the Club then adjourned until September.

New York Railroad Club.

The regular monthly meeting was held in New York, May 17. The subject for discussion was Freight Car Couplers with special reference to the comparative merits of the hook and link-and-pin couplers.

American Society of Mechanical Engineers.

The Eastern members attending the Nashville meeting left New York in a special car over the Erie line. On their arrival at Cincinnati they were met and entertained by a local committee, of which Mr. W. H. Doane was Chairman.

The meeting at Nashville began on Tuesday, May 8, at 10 A.M., President Horace Lee in the chair.

After the announcement of the new members elected, the first paper on the docket, A Safety Car-Heating System, by H. R. Towne, was read. The paper was discussed by F. R. Hutton, J. L. Gobeille, H. P. Minot, and William Kent, chiefly on the joints and fastenings.

William J. Baldwin's paper, Notes on Warming Railroad Cars by Steam, followed, but elicited no discussion.

Then J. T. Hawkins read a paper on Automatic Regulator for Heating Apparatus. This paper drew forth a long discussion, which tended to show that hot-water systems are largely and successfully used in Canada, and are gradually meeting with increased favor in this country; that a good positive regulator is needed, and that all attempts to regulate the temperature at the radiator were unsuccessful.

Mr. Hawkins then read a second paper on A Plea for the Printing Press in Mechanical Engineering Schools. This paper was discussed by Messrs. Kent, Cobb, Reese, Hutton, Macgruder, Gobeille, and Sweet, and tended to show that in technical schools subjects were selected that would give the greatest amount of training, and that could be carried to a complete end, which could not be done with a subject like the printing press, in the time allowed.

A paper on Estimating the Cost of Foundry Work, by George L. Fowler, was then read, and was followed by a paper on A Short Way to Keep Time and Cost, by H. L. Binsse.

In the afternoon the members visited Fisk University and the plant of the Nashville Iron, Steel & Charcoal Company. Under the patents of Dr. H. M. Pierce, the gases from these charcoal kilns are utilized for the production of wood alcohol, acetate of lime, and some of the tartaric compounds, while the incondensable gases are returned to the kilns or fired in the furnaces.

WEDNESDAY'S SESSION.

The first paper was by R. H. Thurston, on Proportioning Steam Cylinders. The discussion tended to prove the author went into unnecessary refinements, since experience gave as accurate results.

William F. Mattes then read a paper on Connecting Rods. C. C. Collins presented one on A New Method of Inserting and Securing Crank-Pins. The discussion favored the method for the peculiar conditions mentioned, and then turned to the subject of shrinkage.

In the afternoon the Society was present at the laying of the corner-stone of the new Mechanical School of Vanderbilt University, and afterward visited the beautiful farm, Belle Meade, the property of General W. H. Jackson.

In the evening the first paper was by George H. Barnes, on the Effect of Circulation in Steam Boilers on Quality of Steam. Professor Jay M. Whitham described a similar instance on board the U. S. Steamer *Galena*.

Mr. Barnes then read the next two papers: Memoranda on the Performance of a Compound Engine and An Electric Speed Recorder.

The Topical Questions were then discussed.

The principal ones, with the result of the discussions, are mentioned below:

59. What data have you for design of hemp rope transmissions, especially where several parallel ropes replace a flat belt? The discussion on this was in favor of round rather than V-shaped grooves; one continuous rope instead of a number of single ones, and the use of a long splice.

62. What are the data derived from experience for the design of the paper-covered friction driving-gear used in the Northwest?

They give about as good results as belts of equal width.

66. To what extent does electroplating reduce the temper of highly hardened steel?

None of the members present had investigated this subject, and the discussion turned to the phenomenon of the spontaneous breakage of steel which has been very highly tempered.

THURSDAY'S SESSION.

A paper by J. M. Whitham was presented on Surface Condensers. Professor Hutton showed a piece of brass pipe from a sugar-vapor condenser, from which the zinc had been apparently eaten out. Mr. Nagle said it was a common experience not to use much brass in refineries, and, if necessary, it could be protected by a coating of paraffine.

This was followed by J. S. Coon's paper, Duty Trials of Pumping Engines. Mr. Barnes moved the appointment of a committee to draw up standard rules for pump duty tests. Carried.

F. W. Dean's paper was then read, on The Distribution of Steam in the Strong Locomotive.

The discussion limited itself to the conditions of the trial, it being generally conceded the time was too short, and should not have included the slowing down for a stop and the restarting afterward.

S. S. Randolph's paper was then read, on Strains in Locomotive Boilers, followed by W. L. Clements's on Steam Excavators, and then J. M. Sweeney presented a paper on River Practice of the West, which was listened to with interest.

In the afternoon the members were taken to see the new water reservoir now building just outside the city limits. Its capacity will be 50,000,000 gallons.

At the evening session the first paper was read by H. de B. Parsons, on The Displacements and Area Curves of Fish. This was followed by J. E. Denton's paper on Mechanical Significance of Determination of Viscosity of Lubricants; then F. A. Scheffler, on A Foundry Cupola Experience; A. F. Nagle, on The Best Form of Nozzles and Diverging Tubes; Jacob Reese, on The Tetra-Basic Phosphate; R. H. Thurston, on Large and Enlarged Photographs and Blue Prints; J. Burkitt Webb, on A Persistent Form of Tooth; and William Hewitt, on Wire-Rope Fastenings.

EXCURSIONS.

On Friday the members boarded a special train furnished by the Nashville, Chattanooga & St. Louis Railroad and visited South Pittsburgh, arriving at Chattanooga in the evening. Saturday was spent in seeing the principal manufacturing industries, and in climbing Lookout Mountain. In the evening, after a reception by the Chamber of Commerce, the special train started Northward, and the session closed upon one of the most successful meetings ever held by the Society.

American Water-Works Association.

The eighth annual meeting was held in Cleveland, O., April 17, 18, and 19, President J. T. Fanning presiding. The first session was held Tuesday morning, and after the transaction of regular business the Society listened to a paper by the President on Water-Supply Treatments and Sources.

At the afternoon session invitations were received to visit works and shops, and a committee was appointed to make suitable arrangements.

The reports of the Executive and Finance Committees were received and accepted.

The Secretary reported that during the last year 44 active, 5 associate, and 1 honorary member had been elected, and that 7 members had been lost by death or resignation, leaving a net increase of 43.

The Society now numbers 210 active, 54 associate, and 1 honorary members.

The last year's total receipts were $1,080, of which a cash balance of $157 remains. This report was approved and accepted.

The death was announced of John Ryle, of Paterson, N. J., and of W. C. Stripe, of Keokuk, Ia. Mr. Stripe was closely identified with the growth of the Society, and was one of its most efficient laborers.

A committee was authorized to prepare obituary memoirs.

Papers were read on Sanitary Protection of Rochester's Water Supply, by Chief Engineer J. Nelson Tubbs; Use of Salt-

Glazed Vitrified Pipe, by S. E. Babcock, and Consumption of Water by Cities and Towns, by H. W. Ayers.

Mr. Y. Nakajima not being present to read his paper on the Water Supply of Tokyo, Japan, it was omitted from the programme, but directed to be printed in the proceedings as appearing with the rest.

The reading of the papers was followed by interesting discussions.

The following officers were elected for the ensuing year: President, A. N. Denman, Des Moines, Ia. Vice-Presidents, J. N. Diven, Elmira, N. Y.; W. G. Richards, Atlanta, Ga.; John W. Hennion, Minneapolis, Minn.; Charles U. Priddy, Leadville, Col.; H. W. Ayres, Hartford, Conn. Secretary and Treasurer, J. H. Decker, Hannibal, Mo.

American Institute of Mining Engineers.

The spring meeting began, according to announcement, in Birmingham, Ala., May 15, the session being opened by addresses of welcome by several gentlemen representing local organizations. President W. P. Potter, of St. Louis, called the meeting to order and delivered an opening address.

On the first day's session several papers were read, including one by W. M. Bowron on the Process and Cost of Manufacturing Iron at the South Pittsburgh furnaces; and one by A. W. Brainard, of Birmingham, on the Cost of Making Iron and Steel in Alabama; both papers were discussed.

The succeeding days were devoted to excursions to the mines in Birmingham, Bessemer and the adjoining districts, and those of the Lower Cahaba coal fields, interspersed with sessions held for business and the reading of papers. The annual dinner took place on Thursday, May 17.

The business session closed on Saturday, May 19, when the members proceeded over the Georgia Pacific to Anniston, visiting the furnaces of the Woodstock Iron Company and other furnaces and factories in that vicinity. The members remained at Anniston over Sunday, and on Monday were taken to visit the furnaces and ore banks of the Clifton Iron Company. which closed the meeting.

Master Car-Builders' Association.

The following circulars have been issued by the Secretary from his office, No. 45 Broadway, New York:

ANNOUNCEMENT OF ANNUAL CONVENTION.

The Twenty-first Annual Convention of the Association will be held in the Thousand Island House, at Alexandria Bay, beginning Tuesday, June 12, 1888, at 10 A.M.

Alexandria Bay is in Jefferson County, N. Y., on the St. Lawrence River, near the outlet of Lake Ontario, and 12 miles from Clayton, a terminus of the Rome, Watertown & Ogdensburg Railroad. Boats for Alexandria Bay run in connection with trains arriving at Clayton. Connections are made at Suspension Bridge, Niagara Falls, Rochester, Syracuse, Rome, and Utica, with the Rome, Watertown & Ogdensburg Railroad. Or persons from the East may go to Ogdensburg by the Ogdensburg & Lake Champlain Railroad, and from there by boat to Alexandria Bay. Passengers on the Grand Trunk Railway can connect by steamboat for Alexandria Bay at Kingston, *viâ* Cape Vincent and Clayton, or at Gananoque or Brockville for Alexandria Bay.

The rates at the Thousand Island House, during the Convention, will be $3 per day to members of the Association and their families, and $4 per day to those who are not members. Those who wish to engage rooms in advance should apply to R. H. Southgate, Hotel Brunswick, New York City, and should state for what length of time they will occupy them.

NOTE.—Members who have not answered the circulars of the different committees are urged to do so as promptly as possible.

UNIFORMITY OF THE INTERCHANGEABLE PARTS OF CARS.

Up to the present time the Master Car-Builders' Association has adopted the following standards:

1. Wheel tread and flange.
2. Diameters of chill moulds.
3. Distance between the backs of wheel flanges.
4. Axle.
5. Journal bearing.
6. Journal box.
7. Pedestal.
8. Gauges for wheels and axles.
9. Gauge for guard rails.
10. Brake shoes.
11. Screw threads.
12. Height of draw-bars.
13. Attachments of draw-bars.
14. Dimensions of dead blocks.
15. Attachments for the safety of train men.
16. System of marking cars.
17. Type of automatic coupler.

There is, unfortunately, a tendency, which seems to be inherent in human nature, to depart from established standards of mechanical as well as moral rectitude. In many cases, when parties have nominally adopted the standards of the Association, they have knowingly or unknowingly departed from them to a greater or less degree. In some cases this has been due to ambition to improve on the action of the Association, and in other cases to ignorance or misapprehension of what the standards really are.

Your Committee has been appointed to consider the question, "How can uniformity in the interchangeable parts of cars be obtained?" and to make a report thereon at the next convention of the Association. They therefore request members to reply to the following inquiries and to make any suggestions which will assist the Committee in reporting on the subject.

1. How can raiload companies secure uniformity to the Master Car-Builders' standard in the shape of tread and flange, and the diameters of wheels which they make or buy?

2. How can Master Car-Builders secure uniformity in the distance between the backs of flanges of their own wheels and those which pass over their lines?

3. Are the gauges recommended by the Master Car-Builders' Association for the maintenance of uniformity in wheels and axles the best that can be devised? If not, what kind of gauges would you recommend?

4. How can journal bearings, journal boxes, and pedestals be made interchangeable and kept so?

5. How can brake shoes be made interchangeable and kept so?

6. How can the screws of bolts and nuts be made interchangeable and kept so?

7. In your opinion is it desirable for the Master Car-Builders' Association to adopt uniform non-automatic draw gear, and if so, should the present standard height of draw-bar and dimensions of dead-blocks be adhered to?

8. In the adoption of the Master Car-Builders' standard type of Automatic Coupler, what steps should be taken to secure uniformity and interchangeability in draw-gear of that kind?

9. Besides those already adopted by the Master Car-Builders' Association, what other parts of cars should be standardized by the Association?

As the time before the next meeting is short, members are requested to answer the above questions promptly.

SAMUEL IRVIN,
HARVEY MIDDLETON, } Committee.
JOHN HODGE,

Replies should be sent to Samuel Irvin, M. C. B., Missouri Pacific Railway, St. Louis, Mo.

NOTICE OF REDUCED FARE FROM THE CONVENTION.

The Trunk Line Association—*outside of the State of New York*—the Central Traffic Association and the Southern Passenger Association have agreed that persons who attend the Master Car-Builders' Convention, from points within the territory covered by these Associations (excepting the State of New York), who pay full fare going to the meeting, shall be returned at one-third the highest limited rate on the above respective Associations' certificates.

Blank certificates will be furnished on application to the Secretary of the Master Car-Builders' Association to persons in the New England States, Pennsylvania, and Maryland. Persons outside of these States, and outside of New York State, can get certificates from ticket agents at points where tickets are purchased. (Certificates will be furnished by the Secretary to parties in the New England States, Pennsylvania, and Maryland, on and after June 1.)

Persons who attend the Convention, from points outside the State of New York, to avail themselves of the concession, must pay full first-class fare going to the meeting, and get a blank certificate to that effect filled in on one side *by the agent of whom they buy their tickets*. They must present this certificate to the proper officer of the Master Car-Builders' Convention at Alexandria Bay for indorsement.

It will be absolutely necessary for each person to obtain a certificate and the signature thereto of the agent of whom the ticket is purchased, to the point where the Convention is held, otherwise the purchaser of a ticket will be unable to obtain the excursion rate returning, and will be obliged to pay full fare both ways. No refund of fares will be made on any account whatever, because of failure of the parties to obtain certificates.

Persons who attend the Convention from points within the State of New York can get excursion tickets from ticket agents for fare and a third without a certificate. Sales will begin on Saturday, June 9, and the tickets will be available for return passage until Monday, June 25, inclusive.

OBITUARY.

OTTO GRUNINGER, who died in New York, April 24, aged 41 years, was a German engineer who first came to this country to examine the construction of the Mt. Washington Railroad, and made a report on that line which practically determined the methods adopted in building the Riggenbach Railroad over the Rigi in Switzerland. He returned to this country some time ago as agent and representative of the Abt rack-rail system of mountain railroads.

SIR CHARLES BRIGHT, who died in London, May 3, aged 56 years, was for all his active life engaged in the telegraphic service. In 1853 he undertook cable work and laid the first line between England and Ireland. Later he was Chief Engineer in charge of the laying of the first Atlantic cable, and was employed in similar work until 1864.

Within the next few years he superintended the laying of cables between the United States and Cuba, and united various parts of North and South America, the West Indies, and other places. In a paper read by him at the Institution of Civil Engineers in 1865, he advocated submarine telegraphs to China and Australia. He was considered a very high authority on all telegraphic questions, and was a prominent member of several scientific societies.

DR. W. W. LAMAN, who died in New York, May 12, aged 61 years, was born in Central New York, and was at one time a physician. He gave up that profession and spent several years in travel in Central Africa, Siberia, and other little-known countries in pursuit of scientific knowledge. On his return he settled in New York City, and became interested in many railroad schemes. At one time he held contingent contracts for over 10,000 miles of railroad. Dr. Laman was, however, inclined to be somewhat visionary, and was not very successful as a promoter, very few of his projects having assumed actual, practical form in his hands, although he possessed great persuasive powers and could always interest others in his plans. His latest schemes were the proposed aqueduct for bringing water from the Adirondack Region to New York City, and the Fulton Street Electric Railroad in New York. The latter is nearly completed, but its opening has been delayed by litigation.

JAMES GILLET, who died at his residence in Brooklyn, N. Y., May 13, was born in Columbus, O., where his parents (who came from Connecticut) had settled a few years before his birth. In 1823, when he was five years old, his parents died, and for 16 years he lived with relatives in Connecticut, working as he grew older on a farm and in a country store. In 1839 he returned to Columbus, and after working in a store for a time, he entered the office of the *Ohio State Journal* as bookkeeper, and also reported for that paper the proceedings of the Legislature of the State. Subsequently he was connected with the editorial department of the paper, and in 1845 he was chosen Secretary of the Board of Control of the State Bank of Ohio. In 1848 he left Columbus on account of his health, and after spending a year in Vermont and six months in Europe went to Florida, where he was for six years in the cotton business. He was then for a time in the lumber business and afterward with Vose, Dinsmore & Co., manufacturers of car springs.

The *National Car Builder* was started by that firm in 1870 under Mr. Gillet's charge as Editor. That charge he retained, under various changes of ownership of the paper, until his death, for he remained at work up to two or three days before the end. Its success was largely due to his intelligent direction and careful supervision of its columns.

The leading traits of Mr. Gillet's character were his strict integrity and conscientiousness; what he said could be entirely relied upon, and no consideration of expediency could induce him to do anything that he did not consider right. He was also a man of wide reading and had much general knowledge, as his friends knew. He had not many intimate friends, but those who knew him best loved him most, and all who were brought in contact with him esteemed him. He leaves no family, his wife and daughter having died several years ago.

THOMAS RUSSELL CRAMPTON, who died at his residence in London, April 19, was born in England in 1816 and studied engineering under the elder Brunel. After several years in subordinate positions he commenced active practice as a Civil Engineer on his own account. In 1848, in the famous discussion over railroad gauges, he took an active part in favor of what is now the standard gauge, opposing the 7-ft. gauge of his old master Brunel.

For some years he devoted himself to the improvement of the locomotive, and in 1847 designed the Crampton engine. An engine of this type was shown at the great Exposition in London in 1851, and for it he received the grand medal. A number of engines of this class were built in England, but in that country they were gradually abandoned. In France, however, the Crampton engine is still in use to some extent. An illustration of a locomotive of this type will be found on another page.

About 1851 Mr. Crampton became interested in telegraph matters, and to his exertions and influence were largely due the laying of the first submarine cable, which was put down under the English Channel from Dover to Calais in 1851. Thenceforward for a number of years his time was largely occupied in telegraph engineering; but he found time to act as consulting engineer for a number of short lines in England, for several of the Turkish railroads, and for the Berlin water-works. His activity was many-sided, however, and he was the inventor of a number of improvements in the manufacture of iron and steel, in brick-making machinery, and in the construction of guns and forts. Although nominally retired from active work for several years, he continued to do as much as his failing health would permit. He was a member of the British Institution of Mechanical Engineers; of the Institution of Civil Engineers; of a number of foreign Societies, and also an officer of the English Society of Telegraph Engineers and Electricians.

PERSONALS.

A. F. NIMS has been appointed City Engineer of Nebraska City, Neb.

W. I. ALLEN has been appointed General Superintendent of the Chicago, Kansas & Nebraska Railroad.

M. A. ORLOPP, JR., has been elected City Engineer of Little Rock, Ark., for the ensuing year.

D. M. WHEELER, of Minneapolis, is now Chief Engineer of the Winona & Southwestern Railroad.

FRANK NICHOLSON, M.E., has been appointed Assayer in charge of the Government assay office in St. Louis.

H. BISSELL has been appointed Chief Engineer of the Boston & Maine Railroad, with office in Boston.

CARY A. WILSON has been appointed Chief Engineer of the East Tennessee, Virginia & Georgia Railroad.

CHARLES S. CHURCHILL is Chief Engineer in charge of the new extension of the Norfolk & Western Railroad to the Ohio River.

S. C. STICKNEY has been appointed Engineer of Maintenance of Way of the Chicago, St. Paul & Kansas City Railroad.

PETER C. HENSEL has been appointed Superintendent of Water Works at Lancaster, Pa., succeeding JACOB HALBACH, resigned.

THE Governor of Kentucky has appointed I. A. SPALDING, A. B. FLEMING, and J. F. HOGAR to be Railroad Commissioners of that State.

STEVENSON TOWLE, for 15 years past in charge of the sewers of New York City, has been appointed a member of the Park Commission of the city.

B. C. LUTHER, Chief Engineer of the Philadelphia & Reading Coal & Iron Company, has succeeded Mr. S. B. Whiting as General Superintendent.

NAVAL CONSTRUCTOR SAMUEL H. POOK has been detached from the New York Navy Yard and placed on waiting orders; he will shortly go upon the retired list.

ASSISTANT NAVAL CONSTRUCTOR JOSEPH H. LINNARD has been relieved from duty in the Bureau of Construction at Washington, and ordered to duty at the Norfolk Navy Yard.

MAJOR N. S. HILL, for many years Purchasing Agent of the Baltimore & Ohio Railroad, resigned June 1, and will engage

in other business. In the reorganization of the company the duties and powers of his office were very much curtailed, and it is understood that this is the reason for his resignation.

ASSISTANT NAVAL CONSTRUCTOR JOHN B. HOOVER has been ordered to duty as Constructor at the New York Navy Yard, and will have special charge of the work on the armored cruiser *Maine*.

D. W. BOWMAN has been appointed Consulting Engineer in charge of the bridges of the Central Railroad of Georgia, with office in Savannah, Ga. He was formerly with the Phœnixville Bridge Company.

G. W. BENTLEY has resigned his position as General Manager of the Jacksonville, Tampa & Key West road, which was largely built through his exertions. He has had a wide and varied experience in railroad work.

DAVID HAWKSWORTH has been appointed Superintendent of Motive Power of the Burlington & Missouri River lines, with headquarters at Plattsmouth, Neb. He will have charge of both the locomotive and car departments.

PROFESSOR M. E. WADSWORTH, Principal of the Michigan Mining School at Houghton, Mich., has been appointed State Geologist for Michigan for one year. He takes the place of the late State Geologist, Charles E. Wright.

A. A. ROBINSON, Second Vice-President of the Atchison, Topeka & Sante Fé Railroad, has been appointed Manager also, and will have charge of the Operating Department as well as of new construction and engineering.

P. F. BRENDLINGER, Chief Engineer of the Pennsylvania Schuylkill Valley Railroad, has resigned that position and goes with Messrs. Brown, Howard & Co., Tarrytown, N. Y., contractors on the Croton Aqueduct, as Chief Engineer.

L. B. WHITING, General Superintendent of the Philadelphia & Reading Coal & Iron Company, resigned May 1. He becomes General Manager of the Calumet & Hecla Copper Mines in the Lake Superior Region of Michigan, with headquarters at Boston.

THE following promotions in the Engineer Corps, United States Army, are announced: CAPTAIN CHARLES E. B. DAVIS to be Major; FIRST LIEUTENANT GEORGE C. DERBY to be Captain; SECOND LIEUTENANT WILLIAM L. SIBERT to be First Lieutenant; SECOND LIEUTENANT EUGENE W. VAN C. LUCAS, late First Artillery, to be Second Lieutenant Corps of Engineers.

R. H. SOULE, on his retirement from the position of General Manager of the New York, Lake Erie & Western Railroad, was presented by the employés of the road with a very handsome watch and chain accompanied by a volume containing a testimonial of respect handsomely engrossed, followed by the signatures of over 4,000 of his friends and well-wishers of the road. At the same time Mrs. Soule was presented with a very handsome cut glass set. Thanks for these gifts were subsequently returned in an appropriate letter. Mr. Soule has started for Europe, where he expects to spend several months in traveling, in order to obtain the rest which he needs.

COLEMAN SELLERS, who several years ago retired from the firm of William Sellers & Company on account of ill-health, has, as his friends will be pleased to hear, so far recovered as to be able to resume active work. Mr. Sellers has been appointed Professor of Engineering Practice in the Stevens Institute of Technology at Hoboken, N. J., and will at once begin his duties there, opening with a course of lectures which is intended to be thoroughly practical. The professorship is a new one, and the Trustees of the Stevens Institute have been exceedingly fortunate in finding a man so thoroughly well fitted to fill the chair in every respect as is Mr. Sellers.

JACOB JOHANN resigned his position as Superintendent of Motive Power on the Texas & Pacific Railroad on June 1. He is one of the best known master mechanics in the country, having been connected with several locomotive works and having filled positions on a number of prominent roads. He has been on the Texas & Pacific for two years, and had previously served on the Chicago & Atlantic; the Wabash, St. Louis & Pacific; the Chicago & Canada Southern and the Missouri Pacific. Mr. Johann has also been a prominent and active member of the Master Mechanics' Association. He served as Vice-President for a year and as Acting President after the death of Mr. Woodcock. He last year declined an election to the presidency. Mr. Johann, we understand, will make his residence at Springfield, Ill., for the present.

NOTES AND NEWS.

A Natural Gas Company.—The Philadelphia Company, operating in Pittsburgh, reports that it is now furnishing natural gas to 791 factories and 22,916 dwellings. For the year ending March 31 the earnings were $1,901,703, and the expenses were $887,061. The dividends (12 per cent.) were $842,627, leaving a surplus of $172,016.

The company's total investment amounts to $9,668,180; its property includes 173 wells, 654 miles of pipe lines, buildings, telephone lines, etc. Besides lands and gas-rights owned in fee, it has gas leases covering 71,444 acres of land.

Blast Pipes for Locomotives.—A recent number of *Industries* gives the following engraving and description of a new variable blast pipe patented in Great Britain by H. Appleby and J. G. Robinson:

"The parts of this apparatus are arranged in such a manner as will allow the blast to be varied at will. The improved blast pipe *A* consists of a central steam nozzle *B*, which communicates with the exhaust of the motor cylinders. The air passage *C* and second steam passage *E* surround the nozzle *B*. The openings *F* for the intake of air are placed at or about the level of the lower row of boiler tubes. The casing *D* is retained in

FIG. 1.

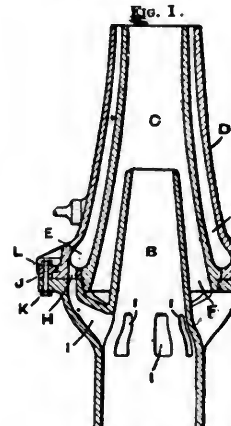
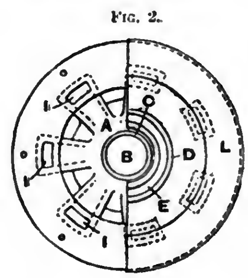


FIG. 2.



its place by the flange *G* and ring *J*, which allow *D* to rotate partially over the lower part of the apparatus. The cap *L* revolves with the upper casing in order to exclude the ashes from its working face. The ports *H* correspond with passages *I*, and lead from the central nozzle *B* to the outer steam passage *E*. When these two sets of ports register with each other, the steam is free to escape by the annular orifice; but upon the external casing being partially rotated, the supply of steam to *E* is more or less intercepted, with the effect of increasing the draft."

A Collision with Dynamite.—A carload of dynamite, on freight train No. 67 of the Philadelphia & Reading Railroad, exploded at Locust Gap, May 5, with terrific force, killing 7 people and wounding 25 others.

The freight train had backed into a siding to allow the passing of the fast line south. When pulling out some of the cars became detached and the train broke in two. The first part waited for the other half to come up, which it did with unexpected violence, the concussion causing the explosion.

Below the road there is a street containing one single dwelling on the north and three double houses on the south. Of these seven nothing now remains, and it was in these that all the deaths occurred. About 100 yards below these buildings there was another row of four double houses which were demolished. Trees near the train were uprooted, while one large tree was blown on top of a freight car.

None of the train hands were injured, although one is said to have been blown a considerable distance.

Railroads in Venezuela.—On March 16 the railroad between Puerto Cabello and Valencia was formally opened by President Hermogenes Lopez.

The Puerto Cabello & Valencia Railroad, as it is called, was commenced a little more than two years ago by Perry, Caruthers & Co., of London, contractors. On April 1 it passed into the hands of the company, of which Mr. W. Mallon is General Manager. The gauge is 3 ft. 6 in.—6 in. wider than the track between La Guayra and Caracas.

The distance is 54 kilometers. Valencia, the southern terminus, is a city of some 40,000 people, and is situated in the heart of one of the richest agricultural regions in the country. In fact, it is admitted that the States of Carabobo and Lara are the first in agricultural development in the entire republic. Another railroad, from Caracas to Valencia, about 300 kilometers in length, is in process of construction by an English company. It is reported that Krupp, of Krupp gun fame, has a concession for still another railroad between the two cities mentioned above.

Another railroad is projected between Puerto Cabello and Aurare, which is not far from the Apure River, one of the principal tributaries of the Orinoco on the north. This is also about 300 kilometers in length.

There is still another line of railroad—already commenced—in this consular district, extending from La Luz to Barquisimeto, a distance of 85 kilometers.—*Report of U. S. Consul D. M. Burke to State Department.*

Baltimore & Ohio Employes' Relief Association.—The following circular from the Baltimore & Ohio Railroad Company explains itself:

"The Act incorporating the Baltimore & Ohio Employés' Relief Association was repealed by an act of the Legislature of Maryland, to take effect on April 1, 1889.

"In order that there may be no apprehension on the part of the members of the Association as to the practical effect of this legislation, it is proper to state that the guarantees of the Baltimore & Ohio Railroad Company for the security of the money in the Savings Fund, and for future deposits, as well as for the rate of interest thereon, remain the same as heretofore.

"The deposits in the Savings Fund on April 1 amounted to $435,166; the Savings Fund Trustees had in their treasury on that date: in cash, $73,893; in B. & O. 5 per cent. mortgage gold bonds, $50,000; while the sum loaned to employés from the Savings Fund for the purpose of building homes, and secured by first mortgages on good real estate, amounted to $317,604.

"The business of the entire Association, including the Building and Savings features, should go on without interruption, and the confidence of its members should not in any way be disturbed by the repeal of the act of incorporation. The Association for the first two years of its existence was conducted without a charter.

"The Baltimore & Ohio Railroad Company and the Committee of Management of the Association will, as early as practicable, take up the question as to whether any modification of the rules and methods of the Association, relating to the Relief Feature, will become necessary on account of the repeal of the charter, and the result made known promptly to its members."

The Pennsylvania Railroad Employés' Relief Fund.—The annual report of the Pennsylvania Railroad Company for 1887 says: "The Employés' Relief Fund, established February 1, 1886, has more than fulfilled the expectations of your management, in the benefits enuring therefrom to such of the employés and their families as have availed themselves of the opportunity thus afforded for relief in cases of sickness, accident, and death. Your Company and affiliated lines contributed during the year $56,701 for operating expenses, and in addition thereto the sum of $1,942 for extra benefits to members of the fund whose disability had continued over 52 weeks, and who were, therefore, no longer entitled to relief therefrom. The amount contributed by your employés was $341,192, the receipts from interest were $5,764, and the contributions by the companies, $58,643, making a total of $405,600, which, added to the balance on hand at the beginning of the year, amounted to $515,407. Out of this fund there was paid to the families of employés in death benefits, and for sickness and accidents, the sum of $266,548, and for expenses $56,701, leaving a balance of $192,158. After deducting therefrom the amount of outstanding unadjusted claims, and setting aside a proper reserve fund to meet liabilities growing out of the increasing age of the members, there remained a net surplus of $111,914. There were 18,744 members of the fund at the close of the year.

"With the view of enabling your employés to safely and conveniently deposit such portion of their earnings as they might desire to accumulate, your Company established, on January 1, 1888, an Employés' Saving Fund, assuming the responsibility of the safe custody and repayment, with reasonable interest, of the moneys deposited. This fund is now in successful operation, and will no doubt, like the Relief Fund, be of value for the purpose indicated."

Chilian Locomotives.—Consul J. W. Romeyn writes from Valparaiso to the State Department as follows: "I have referred incidentally to the building in Chili of certain locomotive engines and cars for the State railroads. I had lately the satisfaction of visiting and inspecting, unofficially, of course, the extensive works of the contractors for the six locomotives, Messrs. Lever, Murphy & Company, at Caleta Abarca, about four miles from this port. Mr. Lever is an Englishman, though formerly a resident of San Francisco. The firm have large capital, have been long established, and have done a great deal of work in repairs on United States vessels of war.

"The wages of their employés, about 450 in number (some 70 per cent. of native birth, the others English, Scotch, and Irish), run as high as $7, Chili money (nearly $4 gold), per day. The locomotives (two still in the shops in a forward state, the four others contracted for having been delivered, the first in December last) are entirely constructed here with the exception of the wheels, which are of English manufacture. The contract price was $40,000 each, about $21,000 gold. Eighteen months was allowed for the construction of all. The general design is the American, with the American truck, and with cylinders on the outside, instead of on the English plan. These cylinders are 17×24 in. Certainly the American engine is much the better adapted to the sharp curves of these mountain roads.

"The machinery used by the constructors for this and other of their metal work is English, that for wood working from the United States. Their steel is imported from England, pig iron for casting from Scotland. Through the kindness of Captain Saukey, an Englishman, but holding the appointment in the Chilian Naval Service of Inspector-General of Machinery, I had the opportunity of inspecting the new steel boilers in construction at the same works for the Chilian corvette *Pilcomayo*, a wooden vessel built in England, and captured from Peru in the late war. The contract price for these two boilers is $52,000 paper currency, about $27,000 gold."

Blast Furnaces of the United States.—The *American Manufacturer* gives its usual monthly table showing the condition of the blast furnaces on May 1 as below:

"The totals are as follows:

Fuel.	In Blast. No.	In Blast. Weekly capacity.	Out of Blast. No.	Out of Blast. Weekly capacity.
Charcoal	60	11,956	114	13,433
Anthracite	104	30,366	96	24,978
Bituminous	133	80,230	87	45,131
Total	297	122,552	297	83,542

"The table shows that there were 12 more furnaces blowing May 1 than on April 1, and that the increase is confined to the anthracite and bituminous furnaces, there being no change in the number of charcoal furnaces in blast. The gain in the anthracite list is 9 and in bituminous 3.

"The appended table shows the number of furnaces in blast on May 1, 1888, and on May 1, 1887, with their weekly capacity:

Fuel.	May 1, 1888. No.	May 1, 1888. Weekly capacity.	May 1, 1887. No.	May 1, 1887. Weekly capacity.
Charcoal	60	11,956	54	10,819
Anthracite	104	30,366	143	40,873
Bituminous	133	80,230	149	86,822
Total	297	122,552	346	138,514

"This table shows the following changes during the year: Charcoal, increase in number of furnaces blowing, 6; increase in weekly capacity, 1,137 tons. Anthracite, decrease in number of furnaces blowing, 39; decrease in weekly capacity, 10,507 tons. Bituminous, decrease in number of furnaces blowing, 16; decrease in weekly capacity, 6,592 tons. Total decrease of number in blast, 49; total decrease in weekly capacity, 15,962 tons."

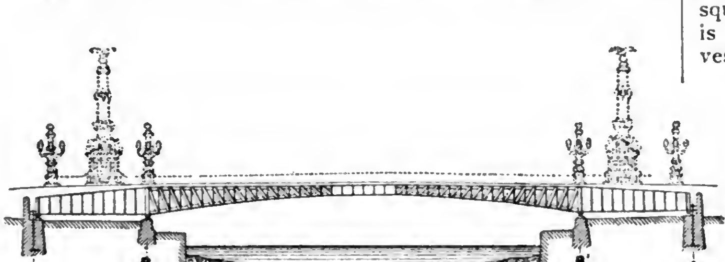
American Steamers for Burmah.—The traffic on the Irrawaddy River, which is the great highway connecting Upper Burmah, which was recently annexed by the English, with the lower province, which has been in their possession for a number of years, is very large. It not only includes the business of the territory bordering on the river, but also that of a large section of country back from it, and some business which is brought from China to Burmah by caravan. This latter, it is

expected, will be largely increased when the proposed railroad from Mandalay is built to the Chinese frontier. The valley of the river is extremely fertile, and has not only a large agricultural population, but also a number of towns and villages, and the Burmese have always been noted for their commercial spirit. The business of the river is at present entirely in the hands of an English company, which runs a number of small steamers of a type not well suited either to the navigation of the river or to the business to be carried; and, furthermore, the number of boats is entirely too small. The company is paying from 50 to 75 per cent. a year on its capital in dividends; but notwithstanding these large profits, it does not seem disposed to increase its investments and the number of steamers.

The Rangoon *Times*, the leading English paper in Burmah, urges that an appeal be made to American capitalists to step in and break the monopoly now held by the Navigation Company, and says that there is no doubt that a number of steamboats of the type used on the Mississippi could find extremely profitable employment. Should such boats be introduced, the *Times* thinks that they would at once take all the business from the English boats on account of their better accommodations, and more suitable arrangements for the traffic, and even should the business be simply divided with the English line, there would be plenty to pay well for the capital required for the enterprise. Should any American steamboat man want to engage in this business, it is probable that reliable information could be obtained from the American Consul at Rangoon, or perhaps in a shorter time by applying to the State Department at Washington.

An Austrian Bridge.—The Stephanie Bridge, which crosses the Danube Canal in Vienna, is of an original and bold design in point of engineering, and a remarkable one in point of architecture and ornamentation. As shown in the cut, it is designed on the principle of a beam fixed at both ends, but more correctly of a continuous girder on four supports, the outer shorter spans being so heavily weighted that, in the most unfavorable case of loading, there is still a pressure of 21 tons on each of the bearings *A* and *A'*. An anchorage is nevertheless provided for at both points, to act in case it should be necessary at any time to remove a portion of the balance-weight. *B'* is a fixed pivot-bearing; while *A*, *B* and *A'* are pivot-bearings on rollers.

The friction of the rollers represents an appreciable force,



which produces bending-moments in the girder and in the masonry block, and it was accordingly introduced into the calculation of the strength of these parts.

The dead-load of the middle span is 466 lbs., and the assumed moving-load 94 lbs. per superficial foot. With these loads, the main-girders are strained with 5.7 tons; the cross-girders with 5.08 tons, and the rivets with 3.81 tons per square inch. A load of 14 tons, on a wheel-base of 11 ft. 6 in. by 5 ft., was also taken into account.

The width of the bridge is 63 ft. 4 in., divided by eight girders, about 7 ft. 9 in. apart. The cross-girders are 5 ft. apart, and on them are trough-irons, laid longitudinally, which support the concrete and wood-block pavement. The balance-weight in the short spans of the girder is constructed of rails and granite blocks.

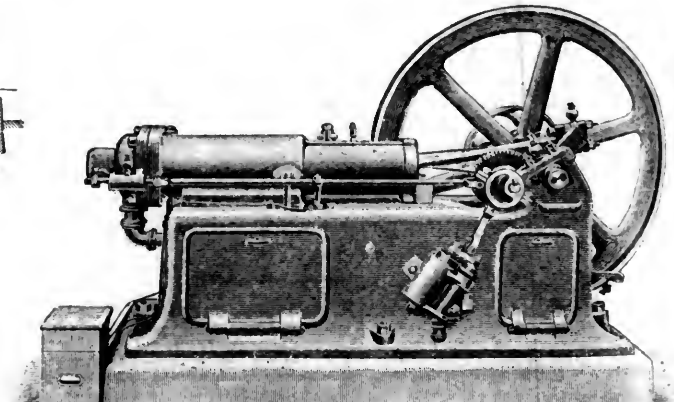
The Engineer is Mr. Oswald Liss, and the Architect, Mr. Otto Hieser.—*Condensed from Allgemeine Bauzeitung.*

Copper Steam Pipes.—The recent accident to the steam pipe of the steamship *Elbe* lends a special interest to the electrolytic process for the manufacture of copper now being practiced by Mr. W. Elmore at Cockermouth. According to the method, such an article as a steam pipe can be produced without weld or joint, and having a tensile strength from 50 to 100 per cent. in excess of first-class brazed pipes. Further, this result can be attained with the use of a very inferior quality of copper, and at a cost which will enable the electrolytically-made article to compete in the market with the customary varieties. Of course there is nothing new in depositing copper in a tubular form, but hitherto such metal has been too brittle to render it reliable for use in circumstances under which it is exposed to great stress. For copying engraved plates, and for the rollers of calico-printing machines, deposited copper has been used with great success, and when it has been thrown down very slowly it has been possible to produce very satisfactory qualities of metal for these purposes. The novelty introduced by Mr. Elmore, however, lies in breaking down the crystals almost immediately they are formed, and pressing them out in a fibrous form in which they are interlaced and matted together. To this end the iron core or mandrel on which the metal is deposited is kept constantly rotating in the bath, and an agate burnisher is slowly wound backward and forward lengthwise of the cylinder as if to put a screw thread upon it. The speeds are so arranged that a layer of copper 0.007 in. thick is deposited between each reciprocation of the burnisher. When the required thickness has been attained the mandrel is lifted out of the bath and placed in a vessel supplied with superheated steam. In a few moments the expansion of the copper detaches it from the iron, and the shell can be stripped off.

Pieces cut from such tubes have been submitted to breaking tests by Messrs. Kirkaldy & Co., Professor Kennedy, and Professor Unwin, and have broken at strains varying from 27 tons to 41 tons per square inch, with an extension varying from 5 to 7½ per cent. in a length of 10 in. The metal can be very easily worked under the hammer, and can be drawn, bent, or compressed without annealing and without any tendency to crack. Specimens polished and submitted to the microscope show that the electrolytic metal has a perfectly compact and homogeneous structure, while drawn copper is a honey-combed mass of crystals, only connected together at points.—*London Engineering.*

The Priestman Petroleum Engine.—Gas engines are used much more in England than in this country, and in some engines recently introduced the gas used is made directly from naphtha or benzine. The latest form of engine makes the gas directly from ordinary petroleum or kerosene, and is known as the Priestman engine, from the name of the maker.

This engine is very simple in construction, having but few working parts. The petroleum from which the motive power is obtained is placed in a closed iron tank inside the foundation. Air is pumped into this tank until a pressure of about 5 lbs. per square inch is obtained. The oil is then mixed with air until it is formed into a vapor, after which it passes into a closed iron vessel, or vaporizer, where it is heated, and from which it is



admitted into the cylinder and ignited by means of an electric spark. This spark is obtained from a small primary battery, capable of doing about 30 hours' work without attention, and which, it is stated, can be renewed at a cost of a few cents. To start the engine it is only necessary to heat the vaporizer for a few minutes, and take a turn or two of the fly-wheel, after which the required temperature is obtained by utilizing the heat from the exhaust products. The cylinder is water-jacketed, the water being contained in the bed-plate of the engine, and circulated by means of a small pump. The engine is self-contained, and after having been started, it runs automatically—that is to say, it prepares its own source of power by pumping air into the petroleum and by atomizing the liquid; it ignites its charge and cools its own cylinder; in fact, it requires no special attention except at long intervals.

It is claimed that this engine can be run at a cost of 1 cent per H.P. per hour, and that it is especially adapted for steam launches, street cars, and other places where space is valuable and where a moderate amount of power is required.

THE RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

PUBLISHED MONTHLY AT No. 45 BROADWAY, NEW YORK.

M. N. FORNEY, ... Editor and Proprietor.
FREDERICK HOBART. . . . . Associate Editor.

Entered at the Post Office at New York City as Second-Class Mail Matter.

SUBSCRIPTION RATES.

Subscription, per annum, Postage prepaid $3 00
Subscription, per annum, Foreign Countries 3 50
Single copies 25

Remittances should be made by Express Money-Order, Draft, P. O. Money-Order or Registered Letter.

MR. J. HOWARD BARNARD, 7 Montgomery Avenue, San Francisco, Cal., is the authorized Western Agent for the JOURNAL.

MR. FREDERIC ALGAR, Nos. 11 and 12 Clements Lane, Lombard Street, London, E. C., England, is the authorized European Agent for the JOURNAL.

NEW YORK, JULY, 1888.

THE Editor of THE RAILROAD AND ENGINEERING JOURNAL is now engaged in collecting material which he contemplates using hereafter in writing a history of American railroads. If any reader of the JOURNAL has in his possession, or knows of the existence of, any drawings or documents available for this purpose—such as drawings of old locomotives or cars, maps, profiles, etc., reports, or any other documents, written or printed—he will confer a favor by informing us of the fact. Any books, documents, or drawings which may be intrusted to the Editor for this purpose will be treated with the utmost care while in his possession, and will be returned safely to the owners.

THE month just closed has been a month of conventions, several of the most important railroad and technical associations having their annual meetings. The Master Car-Builders' and the Master Mechanics' Associations both met at the Thousand Islands, and the Car Accountants' Association at Montreal, while the American Society of Civil Engineers is holding its Annual Convention at Milwaukee as the month closes, and several less important societies are also on the wing.

Some men are disposed to disparage the importance of these annual gatherings, and to insinuate that more time is given to pleasure than to business. It is true that the actual results sometimes seem small, but it is also true that the opportunity given to busy men to leave for a short time their daily routine of work is worth a great deal. The friction of minds, and the interchange of new ideas is, after all, the best result of the conventions, and does much good to the members which is not expressed in the reported proceedings.

IT would naturally be supposed that the Traffic Associations, under whose charge so large a part of the passenger business is conducted, would be willing to favor a meeting of railroad men by giving every possible facility to those who desire to attend it. This should be especially the case with the meetings of the Master Car-Builders' and the Master Mechanics' Associations, whose deliberations are of so much service to the railroad companies. This year, however, it would seem as if every possible obstacle had been put in the way of those associations, at any rate so far as the granting of special rates and privileges was concerned. Excursion rates were granted and then withdrawn, and the grants renewed at the last moment, in such a way that all the arrangements were thrown into utter confusion, and the Secretaries of the two associations were unable to say what could, or what could not, be done. Independently of any consideration of the special claims of the Master Car-Builders and the Master Mechanics, it must be said that the manner in which this business was conducted is not calculated to give outsiders a favorable opinion of the management of the passenger business under their charge. The associations charged with such extensive and important interests should certainly be so organized as to be able to act promptly and with understanding upon matters coming before them, and, at any rate, should be able to give a definite decision without making continual and confusing changes. If it were not possible, or not advisable, to grant the railroad men special rates, a prompt and courteous refusal would have been very much better than the actual course which was taken.

Exception should, perhaps, be made in the case of the Southern Railroad & Steamship Association, which granted all that it could, freely and without delay.

THE committee which was appointed at the preliminary meeting of railroad accounting officers in Washington, has prepared a plan for the organization of an association and has called a meeting to complete such an organization, to be held in New York in July. The only wonder is that such an association was not formed long ago. In addition to the advantages to be obtained by comparison and discussion of methods, there are many other points which will at once suggest themselves, such as the arrangement of better methods for the prompt settlement of claims; the establishment of a uniform system of accounts for joint traffic; the adjustment of joint accounts, and the attainment of uniformity in accounts and returns. So large a proportion of railroad traffic now is through or joint traffic passing over several different roads, that some uniform system was long ago almost a necessity, and that its establishment through an association has been delayed so long is something not easy to account for.

Whether a general clearing-house system like that in use in England is practicable in this country is a question; the new association may lead in time to the establishment of such a system, as its discussions make it clear that nothing less will accomplish the desired objects.

THE steamer *Etruria*, of the Cunard Line, has succeeded in making the fastest passage on record across the Atlantic, having made the run from Queenstown to Sandy Hook in 6 days, 1 hour and 55 minutes, which is 2 hours and 47 minutes less than the time made by the *Umbria* of the same line not long ago.

The average speed of the ship on this voyage was 470 knots a day and 19.6 knots an hour, the actual distance steamed being 2,854 knots. The best day's run was 503

knots, an average of 20.9 knots an hour, an extraordinary rate of speed.

THE survey of the Nicaragua Interoceanic Canal is now practically completed. The line which will probably be adopted is substantially the same as that indicated by the preliminary reconnoissance made in 1885, the changes being slight. The actual amount of excavation required will be somewhat less than had been supposed, and in every respect the result of the survey was very satisfactory.

AN attempt is to be made to open a regular line to run between Chicago and Liverpool without transshipment. The steamer *Rosedale*, which recently arrived at Montreal from London, is to proceed directly to Chicago by way of the St. Lawrence River and the Lakes. The ship is a steel vessel 180 ft. long, 56 ft. beam, and 21 ft. depth of hold, and is small enough to pass the Welland and the St. Lawrence canals. She brings a load of cement from Liverpool, which is to be delivered in Chicago, and will return with a load of grain. This vessel, it is claimed, will be the first steamer which has ever gone from Liverpool to Chicago direct.

Several sailing vessels have made the voyage from Chicago to Liverpool and return, and at one time, some twenty years ago, there was considerable talk of the establishment of a direct line of this kind. It was found, however, that the vessels best adapted for the lake service did not possess the qualities required for a transatlantic voyage, and that the necessary transfer of cargo was in the end a much more economical arrangement than it would have been to build ships capable of making the entire trip, so that the experiment never resulted in anything further.

SEVERAL of the railroads running to New York are making considerable improvements in their terminal facilities. The Erie completed a new station in Jersey City last fall; the Delaware, Lackawanna & Western is building one at Hoboken, and the Pennsylvania contemplates the construction of a new station as soon as certain questions about the road through Jersey City are decided on. When all these improvements are made, however, it will remain a fact that New York has no terminal station which is worthy so large and important a city. At the best the stations on the Jersey City side of the Hudson are makeshifts, inferior to many which may be found in cities of less importance, while the Grand Central, the only terminal station really within the city limits, although somewhat improved by the recent addition, is a monument of bad design and awkward arrangement, and is far inferior in everything but size to the Providence, or the Lowell Station in Boston, the Broad Street Station in Philadelphia, and many others which might be named.

BUFFALO is one of the cities which are now wrestling with the grade-crossing question. No less than 22 lines enter the city, and it is a necessity for most of them to reach the water front. No definite system has been followed in laying out the roads, and the consequence is that the numerous grade crossings of streets and tracks have become an intolerable nuisance. Some time ago a commission was appointed to prepare a plan for improvements, and to negotiate with the railroad companies for its general adoption by them. The plan which has been prepared by this commission includes a belt line connecting all the roads, a single line into the city and new union passenger and freight stations on a scale large enough to provide sufficient room for the business for years to come. It will not interfere with the lines to the coal docks and elevators on the water front, but it will concentrate in one place the business now done at half a dozen or more different points, and will do away entirely with the numerous grade crossings of streets now existing.

WORK has been begun on the sinking of the track of the New York Central Railroad north of the Harlem River, which is to make a depressed line between five and six miles in length, and to separate the tracks from the street crossings in the same way as was done a number of years ago on the road from the Harlem River to the Grand Central Depot. This work will take some time to complete, as it must be carried on without disturbing or interrupting traffic on the present track. It has been urged upon the company for some time, and has, in fact, been made a necessity by the rapid growth of the section of the city known as the Annexed District.

In this connection it might be suggested that it would be a wise thing for the company to arrange for some other crossing of the Harlem River than the one now in use. The whole passenger business of the Central road is now carried across the Harlem on a bridge, and is subjected to continual and vexatious delays by the opening of the draw for the passage of vessels. These delays necessarily will be very much increased when the improvements of the river are completed, and vessels of large size are enabled to go up the river and pass through the new channel to the Hudson. A high bridge is impossible, but it does seem as if a tunnel under the river could be arranged in connection with the depression of the tracks. Such a work would be expensive, not so much for the tunnel itself as for the approaches which would be needed, but it would probably pay for itself in a short time in the prevention of delays and the freedom from accidents. A collision between a vessel and the draw-span of the present bridge, which is possible, and even probable at any time, would stop the entire traffic of the road for a day or more, causing loss and inconvenience which would be almost incalculable. The whole location of the road from the 125th Street Station to Mott Haven, including the junction between the Harlem Division and the Main Line, is not an example of the engineering which ought to exist on so important a line, and the beginning of the new improvement would seem to be a good time for a general revision of the location and the establishment of a line which would be a credit to the company and its officers.

AN examination of the *Official Guide* for June shows that the fastest trains now on the time-tables are two on the Baltimore & Ohio Railroad, which are timed to run the 40 miles from Baltimore to Washington in 45 minutes, without stops, making the rate of speed 53.3 miles an hour. No other train can be found which makes over 50 miles an hour, and the nearest approach to it is a train on the Pennsylvania Railroad, which runs from Jersey City to Philadelphia, making one stop, at an average speed of 48.3 miles an hour. On the opposition—the Bound Brook—line one train makes the distance from Jersey City to Philadelphia at the rate of 45.9 miles an hour, without allowance for the four stops. The quickest train between Philadelphia and Baltimore runs at the rate of 41.6 miles an hour.

The fastest long-distance run is that of the Chicago Limited on the New York Central & Hudson River Road, which averages 41.6 miles an hour from New York to Albany, and 40.6 miles from Albany to Buffalo. The corresponding train on the Pennsylvania road runs at the rate of 38 miles an hour from Philadelphia to Pittsburgh.

The trains which are timed to run over 40 miles an hour are thus found to be very few in number, and there are not many which are called upon to make more than 35 or, indeed, over 30 miles for any considerable distance. It must be remembered, however, that a train whose average speed is 40 miles an hour must make much faster time than that in parts of its run.

What is the slowest passenger train in the *Guide* is not easy to determine, but an "express" on a North Carolina line, which takes 9 hours to run 100 miles—an average of 11.1 miles an hour—is a very promising candidate for the honor.

THE importance of the coal-mining industry of the United States is shown by the figures for 1887, which have been compiled by Mr. C. A. Ashburner for the United States Geological Survey. The total output of coal last year was 123,965,000 tons, and its value at the mines is estimated at $173,531,000. Almost one-third of the output and more than one-half of the value was furnished by the anthracite mines of Pennsylvania, their product being 39,506,000 tons, valued at $79,365,000. Pennsylvania, indeed, mined more than half the entire amount, its bituminous production being 30,867,000 tons, making with the anthracite a total of 70,373,000 tons. The output of the mines of Ohio was 10,302,000 tons, and of those of Illinois, 10,279,000; no other State produced as much as 5,000,000 tons. Coal was mined in 30 States and Territories, although in nine of them the quantity produced was very small.

THE very unfavorable reports of earnings of railroads now coming from some of the Western and Southwestern railroads show the effects of the over-building of new roads, which has been going on for several years past. Both sections of the country are growing rapidly, and there has been a large increase of traffic, but their business has been so divided up that the new lines have lacked support, and competition has been so sharp that rates have been reduced in many cases to such a point that the traffic will barely pay the expenses of doing it, and will leave nothing for the investors in such lines. Of course this state of things will be partly remedied in time by the growth of the country, but for the competition of parallel lines and the lowering of rates there is not much hope of a remedy.

Experience has shown that in this country it is much easier to reduce rates than to raise them, and, in many cases, the attempt to increase charges to a fair figure has had the effect of arousing enmity against the railroads which has done almost as much harm as the low rates. Competition is an excellent thing in its way, but in the case of many of our railroads it has been carried entirely too far, not only for their own benefit, but for that of the people they serve.

STATE control of railroads, which prevails so extensively on the Continent of Europe, does not appear to meet with much favor in England. It may be remembered that in the General Railroad Act, which was passed by Parliament in 1844, it was provided that the Government might acquire possession of railroads under certain conditions, the provisions being very similar to those embodied in most of the early railroad charters in Massachusetts, New Jersey, and several other States in this country. Recently a motion was made in Parliament for the appointment of a commission to take into consideration the question of "acquiring the railroads of the United Kingdom in accordance with the provisions of the Act of 1844," the mover of the resolution advocating it in an elaborate speech, but it met with so little support that after a brief debate it was negatived without a division.

Incidentally it was said in the debate that the total capital invested in the Kingdom of Great Britain was £830,000,000, and that the average return upon this capital was about 4 per cent. It was also stated that under the present system the interests of English manufacturers were injured by the high charges on the railroads of the country, the average rate per ton-mile in England being more than double that of the United States, very nearly double that of Belgium, 50 per cent. higher than that of Germany, 30 per cent. than those of Holland and Italy, and higher than in any other European country, with the exceptions of France and Sweden. The reasons given for the high freight rates were three: the comparatively short hauls on English railroads, the heavy terminal expenses, and the fact that the railroads in England are owned by private corporations, and are operated entirely for the purpose of making money, and not for the benefit of the people. This last condition, it was argued, might be changed should the Government own the railroads.

As shown by the division, however, the feeling in Parliament was evidently very strongly against any proposition of this kind, and there is no probability that it will be renewed.

The argument that the roads would be operated for the benefit of the people under State ownership does not meet with much support from experience in France and Germany, where complaints are quite as frequent against the State railroads as the private lines. The fact is, that in Europe, as elsewhere, when a man advocates railroad management for the benefit of the people he generally means by "the people" the particular class which he represents. State management has never met with favor in England, although State control has many advocates.

THE Army Appropriation Bill, which is now before the House of Representatives, contains nothing of very special note except an appropriation of $400,000 for the purchase of dynamite guns, and another of $100,000 for the examination and testing high power shells and explosives. These appropriations have been added in committee, and are in addition to the amount authorized for new ordinance of which we have already spoken.

THE Navy is to have some more new ships, if the appropriation bill passes Congress as reported by the Naval Committee. The bill contains appropriations and authority for letting contracts for four new ships in all, two unarmored cruisers of about 3,000 tons displacement, and of guaranteed speed of not less than 19 knots; one unarmored cruiser of about 5,000 tons to be guaranteed 20 knots; and one heavily armored ship of 7,500 tons displacement, to be capable of making about 17 knots an hour. The bill provides that one of the vessels must be

built in a navy yard, and all of them may be, if the President should so direct. Three of the new vessels authorized are of the class which is likely to be of the greatest use to our Navy.

Fair progress is being made with the new guns for the Navy, as will be seen from the notes printed on another page.

THE contest between armor-plates and projectiles has been renewed abroad, and some recent experiments with steel and composite plates made in England, seem to indicate that for the present the projectiles have the worst of it. On the other hand, it is announced that the Krupp Company is now building at Essen the largest gun yet made ; it is for the Italian armor-clad *Sardegna*, and will weigh 139 tons, will be $52\frac{1}{2}$ ft. long, and have a bore of 15.7 in. This gun will, it is stated, fire a steel shell weighing 1,630 lbs. with an initial velocity of 2,630 ft. per second, or a heavier shell of 2,300 lbs. with an initial velocity of 2,100 ft. It is expected by the makers that this projectile will be able to knock out of time any armor-plate now afloat, and that there will then devolve upon the other side the problem of building a vessel which can float armor-plates heavy enough to resist these shells.

Hudson River Passenger Business.

IN the competition between the railroads and the water routes for business in this country the railroads, so far, have had decidedly the best of it, at any rate so far as passenger business is concerned. The Mississippi, the Ohio, the lower Missouri, and many other Western rivers are now more or less closely paralleled by railroad lines, and the river passenger trade has practically fallen away to almost nothing ; and the same is the case on many of our Eastern rivers, where the steamboat lines formerly had a considerable business.

The Hudson River is naturally the finest river for passenger travel in the world, but the railroads on either bank have taken away the larger share of the traffic which it ought to carry. The better time which they are able to make for long distances has had at least something to do with this, while for through travel the avoidance of a break or transfer in the course of the journey has also assisted the railroad competition. Nevertheless, there is still a very large passenger business carried between New York, Albany, and the towns and cities on the upper part of the river by the numerous lines, and their flourishing condition shows that the steamboat business is not an unprofitable one. On the lower portion of the river, however, from Newburgh down, the river passenger business has practically disappeared, and the number of travelers, excepting excursionists, who take the boats there is insignificant ; substantially all the business from the towns on either side going to and from New York by rail.

It is impossible to resist the belief that this has been largely the result of mismanagement. From New York to and through the Highlands the river is closely dotted on both banks with flourishing towns and villages, having a large population in close connection—many of them daily travelers to and fro—with the City, and for one-half of the year this population is fully doubled by summer residents. To many of these people the steamboat trip would be far preferable to that by rail, were there any comparison between the time and the conveniences afforded for travel.

It would seem as if the steamboat men had deliberately thrown this business away by their obstinate adherence to old methods. The boats which have been employed in the business have been nearly all of them of old style and inconvenient, and no effort seems to have been made to replace them by better ones, while the running schedules have been more in accordance with the needs and the habits of 25 years ago than the present time. It seems as though they had deliberately abandoned the field to the railroads without one single effective effort at competition.

On a river so wide as the lower Hudson, a boat making landings on both sides must necessarily lose a great deal of time, and the loss is largely increased by the changes and chances of wind and tide. Nevertheless the steamboat men have gone on making the landings in this way with their unwieldy boats, and have been apparently surprised when they found that people would not travel by them because they took too long to make the trips.

It would seem as if there was now on the Hudson River a field well worth cultivation. Fast boats with modern machinery, which could be economically managed, making landings on one side of the river only, and not making too many, would be able to reach almost the time of a way train, either on the Hudson River or the West Shore road. The boats should be small enough to be able to pick up a living business from a few landings, and so could avoid the delays consequent upon taking in all the villages. They could be very economically run, would cost less both to build and to work than the old style boats, and could, at a reasonable expense, be made very attractive to passengers. On the Hudson River below the Highlands a boat can be run for eight months in the year, and for six months of that time the travel is large, so that the amount lost in interest, etc., while the boat is laid up for the winter, would be comparatively small.

It would seem hardly an open question that one or two such lines once established would be so profitable that they would soon be followed by others, and that in a few years, by proper management, not only would a large proportion of the business once done on the river be restored to it, but an important addition would be made to the prosperity and the population of the river towns and villages, which are not now, as a rule, growing as fast as some other much less attractive regions within an equal distance from New York ; so that an apparent temporary loss to the railroads might be followed by a permanent gain to all.

National Railroad Reports.

IN a circular which is given on another page, the Interstate Commerce Commissioners announce their intention of carrying out that clause of the law which empowers them to require from the railroad companies reports in relation to their business and financial condition. The object of the law is that information so obtained may be properly arranged and tabulated, and may then be used by the Commissioners for their own information, or for the instruction of Congress in preparing further legislation. The Commissioners have prepared a form of report which they expect to send to every railroad company in the United States, whether its line is wholly within one

State, and thus beyond their immediate jurisdiction, or whether it is actually an interstate line, with the expectation that all of them will give the information desired, without raising the point as to whether they come within the operation of the law.

The Commissioners hope in this way to secure a body of statistics in relation to all the railroads in the United States, which shall be put in uniform shape, and which shall have the value which attaches to statements officially made and vouched for. Their object is an excellent one, and if it is properly carried out it will furnish a mass of information about the railroads of this country, such as has never been collected up to the present time. The reports which the great majority of railroad companies make have hitherto been entirely voluntary. In some of the States they are required to make yearly returns to railroad commissioners; in Massachusetts the Commission some years ago finally adopted a very excellent form for these returns, the answers to their questions necessarily showing in an intelligible form the real financial condition and the course of business of every railroad in the State. Two or three other States have adopted substantially the Massachusetts form, but in all the others in which reports are required they are made in such a loose and imperfect shape as to have no practical value.

Beyond this there may be said to be no official statements of railroad business in this country. *Poor's Manual*, great as its value is to owners of railroad property or to would-be investors, is not an official publication, and its compilers are necessarily obliged to obtain their facts from railroad companies, and to take such information as their officers may choose to give, without the opportunity or the ability to verify these statements. A considerable number of companies publish annual reports, which are issued to their stockholders; but, unfortunately, it is only too evident to any one familiar with the subject that many of these reports either give very little information, or are—sometimes by intention, more often through inexpertness of the compilers—so misleading in their statements that their value is very small. A few companies—such as the Pennsylvania, the Union Pacific, under the present management, and some others which follow in their footsteps—send out reports which are models, but in other cases the real condition of the company is so covered up by a mass of confusing details that no one but an expert accountant can understand them, and to the average stockholder they are about as much use as a Greek manuscript would be.

To the person who is not interested in any particular road, but who desires to make a general study of the business of the country, such reports as these of individual companies, even the best, are of use only as indications of the general drift of things, and he has heretofore been obliged to give up the subject in despair, or to content himself with such approximations to the truth as he may be able to reach by a laborious system of reasoning, inference, and guesswork.

The condition of railroad statistics of this country can be best expressed by noting that the publishers of a popular magazine recently issued a little card containing 20 questions in relation to railroads: to at least half of these questions there is no living man who can pretend to give accurate answers, and the replies, which the publishers have gathered from some of the best informed men in the country, are merely approximations.

It is not to be expected that the labors of the Interstate Commerce Commission can remedy this state of things in one year or two, but the collection of official reports on a uniform plan for the whole country will be a great step in advance. It is to be hoped that the railroad managers will recognize the fact that it is to their own interests to make such statements as complete as possible, so that in the course of a few years it will be possible to obtain for the first time correct and comprehensive statements of the entire railroad business of the United States.

HALF A CENTURY AGO.

JUST one-half a century ago, in 1838—when the JOURNAL was six years old—a census of all the steam-engines of every description in the United States was taken. This work was done in pursuance of a resolution of Congress, the object apparently being to secure information upon which could be based a law for the regulation of the use of steam; and it was, in fact, shortly after that time that the first general law in relation to steamboats was passed. The census was taken by the collectors of customs in the different districts, and appears from the report which was submitted to Congress, a copy of which is now in our possession, to have been pretty carefully done. It is curious to look over the figures now, and to contrast them with some of those for the present year.

In his preliminary statement the Secretary of the Treasury says that full reports have been received from all the States except Mississippi and Tennessee, in which two or three districts were missing; and that they were somewhat imperfect from the States of Illinois and Arkansas and the Territories of Wisconsin and Iowa. An estimate is made, which is probably a pretty close one, for the missing districts, in several of which it is considered that the absence of returns was due to the fact that there was nothing to return; that is, that there were no steam-engines there.

The summary, including estimates, informs us that there were then in the United States 800 steamboats, 350 locomotives, and 1,860 stationary steam-engines, but these were very unevenly distributed. The largest number of the stationary engines in any one State was in Pennsylvania, where 383 were found, some of them in factories, but a considerable number employed as hoisting and pumping engines in the coal mines, which were already beginning to be an important industry. Curiously enough, Louisiana stood second among the States in her stationary engines, having not less than 274, or about one-sixth of the whole number in the United States. At first sight it appears strange that a State which has never been noted for its manufactories should have had—at that early day—so many engines, but this may be explained by two causes: one, that a large number of small engines were employed on the numerous sugar plantations of the State for crushing cane and similar purposes, and another being that in so level a region there is almost an entire absence of falls which can be utilized for water-power. Thus in Massachusetts, which was considered at that time the leading manufacturing State, there were only found 165 stationary engines; but this is not surprising when we remember that a large proportion of the mills were run by water-power. New York was fourth on the list, having 87, while Ohio already had no less than 83.

The number of steamboats in service, as already stated, was 800. Nearly all of these were employed in river and inland navigation, very few being sea-going vessels or, at least, employed on ocean routes. Not one of the number had crossed the Atlantic, but in New York five were registered as plying between that port and Wilmington, Charleston, Texas, New Orleans and Natchez; the last, by the way, would be considered rather an unusual route for a steamer nowadays. In Philadelphia there were four steam vessels which ran between that place, Wilmington and Charleston; in Baltimore two were owned, forming a line to Charleston and Savannah; two coasting steamers were owned at Wilmington, N. C., and two at Charleston.

The Secretary expressed considerable surprise at this, in consideration of the fact that the first steamship—the *Savannah*—which ever crossed the Atlantic had been built in New York 19 years before, and that the voyage had been successfully made by other steam vessels since that time. The *Sirius*, in fact, had opened the first steamship line between New York and Liverpool, and was soon to be followed by the *Great Western*.

The United States Government at that date owned one sea-going war steamer, the *Fulton*; it also owned 13 steamboats employed in the service of the various departments.

In the number of steamboats New York led all the States, having 140 reported; the larger number of these were returned from New York City, and were employed on the Hudson River, Long Island Sound, and the adjacent waters, though already a considerable number of lake steamers were registered at Buffalo. Pennsylvania came second with 134 steamers, a few being owned in Philadelphia and two or three at Erie, but the majority belonging in the Pittsburgh District and being employed on the Ohio and Mississippi and their tributaries. Ohio was the third State in the number of steamers, owning 79, and 41 belonged in Kentucky, no other State possessing an equal number.

The largest steamboats then owned in the United States, which are mentioned in the report, are the *Natchez* of 860 tons measurement and 300 H.P., which was employed on the route from New York to Natchez mentioned above; the *Illinois* of 755 tons and the *Madison* of 700 on Lake Erie; the *Massachusetts* of 626 tons plying on Long Island Sound. These are small vessels compared to the great lake and river steamers of the present day.

Then, as now, the chief source of accidents on steamboats seems to have been either the defective construction of boilers or the tendency to work them too hard. The accidents mentioned in the reports are nearly all from boiler explosions, and the legislation proposed or at least recommended by the Secretary related almost entirely to the care of the boilers, the regulation of the material to be used and the pressure to be employed, with provision for frequent inspection.

The most interesting part of the report to us, however, is that which enumerates the number of locomotives, of which there were 350 reported. More than one-quarter of these were in Pennsylvania, and were used on the short coal roads in the eastern part of that State, although a considerable number were on the road from Philadelphia to Columbia and on the Reading road. The Portage Railroad crossing the Alleghanies was operated by stationary engines hauling the cars up inclined planes. Massachusetts came second with 37 locomotives; Virginia, third, with 34; New Jersey, fourth, with 32—most of them on the Camden & Amboy; Maryland, fifth, with 31, nearly all Baltimore & Ohio engines; New York, sixth, with only 28, and South Carolina, seventh, with 27. No other State had then more than 10 locomotives owned within its limits. The engines in New York were on the Long Island and Harlem roads—then the only lines running out of New York City—and on the Mohawk & Hudson and the other short lines running westward from Albany, which now form part of the New York Central.

These 350 engines were employed on 1,500 miles of road, and form a very striking contrast to the 29,500, the estimated number in the United States at the beginning of the present year.

It might be curious to note, however, that the number of locomotives has really increased very little faster than the mileage of railroads. In 1838 the average number was one to 4¼ miles of railroad, while in 1888 it is only a very small fraction over one to 4⅓ miles. This, however. does not make any allowance for the increased power of the average locomotive of to-day over that of the engines employed 50 years ago.

In relation to locomotives, this old report is not as full as might be desired; this is, perhaps, to be expected, as the information called for related chiefly to steamboats, and the regulation of Interstate Commerce other than that by water was not then the pressing question which in these later years the development of railroads has made it.

Very little information is given as to the size of the locomotives, although in some cases their horse-power is enumerated, which is, however, rather an indefinite guide. The largest given were rated at from 20 to 25 H.P., although a few on the Boston & Providence and the Boston & Worcester ran as high as 30. The New York railroads did not require so much power apparently, for the heaviest locomotive given on any of them was rated at 20 H.P.

Some of the locomotives were built in England, but the majority at that time were of American manufacture. The firms of Baldwin and Norris, in Philadelphia, had already begun to make a name; the Locks & Canals Company in Lowell was engaged also in the building of locomotives, and a number of other makers appear in the list given—as Garret & Eastwick, Philadelphia, the New Castle Company, Bolton & Company, and one or two firms in Boston which have either ceased to exist or have gone out of the locomotive business.

Some attempt appears to have been made to collect statistics in relation to accidents on railroads, but it was so slight and the results were so imperfect as to be hardly worth recalling. Two accidents, it is stated in the report, had occurred up to that date from the explosion of locomotive boilers, and other accidents are referred to incidentally, but not described.

Although no direct statement to that effect is made in the report, it is very evident from its general tone, and from many indirect references made in it, that while much interest was felt in railroads, they were regarded then as entirely subordinate and inferior in importance to steamboats and river navigation. The steamboat was the great vehicle of commerce wherever it could be used, and the railroad, like the highway road, was useful chiefly as an auxiliary or feeder to the water lines. No one then anticipated to what an extent the railroads would take business away from the steamboats, and the prophet who then predicted the construction and successful working of rail-

roads parallel to such highways as the Hudson or the Mississippi would have had very little credit in his own country —or elsewhere.

NEW PUBLICATIONS.

TABLES FOR FIELD ENGINEERS, DESIGNED FOR USE IN THE FIELD: BY AMOS STILES, C.E. New York; published by D. Van Nostrand (price, $2).

This volume contains three series of tables, the first giving radii and their logarithms, tangential offsets, and middle ordinates; the second containing chords, versed sines, external secants, and tangents of a 1° curve for every minute of angle from 0' to 90°; the third giving natural sines and tangents to every degree and minute of the quadrant.

These tables are preceded by general explanations and a number of problems showing the uses to which they may be applied in field and locating work. These problems are briefly stated, and the application of the tables shown without any attempt at mathematical demonstration, which would, indeed, be hardly possible within the limits of the book.

The Author says: "It has been our endeavor to set forth with clearness some of the abridged methods found so convenient and easy in connection with the building of some of the most extensive railroads in America."

The book is bound in pocket-book form, and is of convenient size; it will be a welcome addition to the outfit of the engineer in the field.

TABLES OF THE PROPERTIES OF SATURATED STEAM AND OTHER VAPORS: BY CECIL H. PEABODY, B.S., ASSISTANT PROFESSOR OF STEAM ENGINEERING IN THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY. New York; published by John Wiley & Sons (price, $1).

These tables were prepared by Professor Peabody chiefly for the use of students in technical schools, but they are of value for engineers also. For saturated steam three tables are given, one in English units for each degree Fahrenheit; one in English units for each pound pressure, and one in French units for each degree Centigrade.

Besides the tables for steam, tables are given of the properties of saturated vapors of alcohol, ether, chloroform, carbon bisulphide, carbon tetrachloride, and acetone. These tables are all given in French units, and are based on Regnault's experiments. In addition, approximate tables are given of the properties of saturated sulphur, dioxide, and ammonia.

An introduction to the tables gives the original data of Regnault's experiments on the properties of saturated steam, and of Rowland's experiments on the mechanical equivalent of heat and the specific heat of water, with the formulæ derived from those experiments.

All of the tabular values given in the book were calculated directly by the aid of these formulæ, without approximation, and have been carried to as many places of significant figures as the data given would warrant. These original calculations were all checked by the method of differences.

The amount of labor involved in the preparation of these tables must have been very great, and will be appreciated by those who have occasion to use them.

ABOUT BOOKS AND PERIODICALS.

THE second article of the Railroad Series, entitled Feats of Railway Engineering, by John Bogart, State Engineer of New York, appears in the July number of SCRIBNER'S MAGAZINE. Mr. Bogart, who is especially well fitted to write on this subject, describes with great force the building of such extraordinary works as the St. Gothard spiral tunnels, the wonderful combination of bridges and tunnels on the Oroya Railroad in Peru, the Niagara and the Britannia bridges, and many other wonderful achievements.

Instead of a lack of material, the writer has had a great superfluity, and has had to use his judgment in selecting such as would be of the greatest interest and profit to the reader.

He describes the Brooklyn, the Kentucky River, the Harlem, the Bismarck, the Niagara, the St. Louis, the Lachine, and the Forth bridges, and the St. Gothard, the Mont Cenis, and the Hoosac tunnels—noted chiefly on account of their great length. One of the most striking examples of bridge construction is the iron Portage Bridge, which takes the place of the old wooden one destroyed by fire, the two examples of iron and wooden construction being shown in the engravings. The old Portage Bridge, by the way, was in itself a great engineering feat, being the most daring example of wooden bridge construction ever undertaken.

A full description is given of the cork-screw tunnel on the St. Gothard Railroad, where, in order to overcome the ascent required, it was found necessary to secure a much longer distance than a straight line or an ordinary curve would give the line, and it was therefore doubly curved upon itself.

The remarkable series of articles on Siberia which are now running in the CENTURY MAGAZINE have, apart from their political bearing, much interest as showing incidentally the material resources of Siberia, and the progress which has been made toward their development. Siberia is, to most of us in this country, merely a name for a cold and barren region only fitted for a penal colony; the truth concerning its great agricultural and mineral resources has been known to very few, and the facts given in these articles are a general surprise. The Southern Siberian line, which is to extend across Asia to the Amoor settlements and the Pacific Coast, will open up some of the richest country yet undeveloped in the world, and any information about it is of interest.

The NORTHWESTERN RAILROADER showed a very creditable spirit of enterprise in moving its headquarters from Minneapolis to Alexandria Bay, and publishing a daily edition during the sessions of the Master Car-Builders' and the Master Mechanics' conventions. The edition contained a report of the proceedings each day, and was out in very good time.

THE POPULAR SCIENCE MONTHLY for July contains an article on Safety in House Drainage which is worthy of a careful reading. The writer seeks to show that there are methods by which all danger to health can be obviated in the plumbing and drainage of dwelling-houses. This is not altogether in accordance with the general belief, but the article makes a strong showing for the other side.

BOOKS RECEIVED.

STATISTICAL ABSTRACT OF THE UNITED STATES, 1887. TENTH NUMBER: FINANCE, COINAGE, COMMERCE, IMMIGRATION, SHIPPING, POSTAL SERVICE, POPULATION, RAILROADS, AGRICULTURE, ETC. PREPARED BY THE BUREAU OF STATISTICS UNDER THE DIRECTION OF THE SECRETARY OF THE TREASURY. Washington; Government Printing Office.

LAND LAWS AND DECISIONS, WITH A REVIEW OF SOME RECENT DECISIONS OF THE SUPREME COURT OF MICHIGAN: BY F. HODGMAN. Climax, Mich.; published by F. Hodgman (25 cents). This is a report made to the Michigan Engineering Society by its Secretary.

DAS NEUE TACHEOMETER, EIN UNIVERSAL-INSTRUMENT FÜR ALLE FELDARBEITEN DES INGENIEURS: VON FRANZ KREUTER. Brunn, Austria; published by Karl Winiker.

SOME POINTS RELATING TO THE EFFICIENCY OF MECHANICAL ENGINEERING SCHOOLS: BY ALFRED R. WOLFF, M.E. Hoboken, N. J.; issued by the *Stevens Indicator*. This is a reprint of the Presidential Address delivered before the Alumni Association of the Stevens Institute of Technology at its last meeting.

SELECTED PAPERS OF THE CIVIL ENGINEERS' CLUB OF THE UNIVERSITY OF ILLINOIS, 1887–88. Champaign, Ill.; issued by the Club; H. Dunaway, Secretary.

WORLD-ENGLISH: THE UNIVERSAL LANGUAGE: BY ALEXANDER MELVILLE BELL. New York; published by N. D. C. Hodges. London; Trübner & Co.

STATE UNIVERSITY OF IOWA: CATALOGUE FOR THE YEAR 1888–89. Iowa City, Ia.; published by the University. This Catalogue shows the University to be in a flourishing condition.

REVISTA DE OBRAS PUBLICAS E MINAS: ASSOCIACAO DOS ENGENHEIROS CIVIS PORTUGUEZES: TOMO XIX. Lisbon, Portugal; published by the Imprensa Nacional.

THE EDSON PRESSURE RECORDING GAUGE AND HIGH-PRESSURE ALARM: THE EDSON TIME AND SPEED RECORDER. CATALOGUE. New York; Jarvis B. Edson, No. 86 Liberty Street.

STORAGE BATTERIES: CATALOGUE AND DESCRIPTION. New York; issued by the Gibson Electric Company, No. 775 Greenwich Street.

THE CENTRAL PACIFIC RAILROAD: ITS RELATIONS WITH THE GOVERNMENT. This is a reprint of the argument made by Mr. Creed Haymond, General Solicitor of the Central Pacific Company, before the Select Committee of the United States Senate, in March and April last.

Hypercycloidal Gear.

To the Editor of The Railroad and Engineering Journal:

IN your JOURNAL for April of this year, I notice an article on "Hypercycloidal Gear," which makes some astonishing claims for teeth generated in a very strange and indefinite manner. The curve used is said to be "one of the cycloidæ, but to describe it in the ordinary manner, the scribing point is made to project beyond the rolling or generating circle, and the curve is scribed across the generatrix or pitch line." This may be all right in a general way, but there is no information given as to what roiling circles are actually used or the exact location of the scribing point in forming the teeth referred to, and the reader is at first in doubt as to whether the Author knows more than he wants to tell, or less than he tries to.

If any point projecting to any extent beyond any rolling circle will produce the mysterious form desired, it naturally follows that the involute and cycloidal teeth in common use are nothing more than special forms of a more general type. But the characteristics stated for the general type cannot be conceded to exist in the special forms mentioned, nor in any other forms whatever, and the question naturally arises—can they be true?

Can a tooth which fits its engaging space as shown in fig. 1 be considered as an admissible form for correct gearing, and, if so, is it possible to apply the same form to wheels of any number of teeth?

To answer this question, we have only to consider that one of the first principles of correct gearing requires that a normal to the surfaces in contact shall always pass through the pitch point p. This condition is necessary to insure a constant velocity-ratio between the engaging wheels, and if a normal to every part of the curve $a\ c$ passes through the pitch point p, it follows that the curve $a\ c$ must be the arc of a circle struck from the center p.

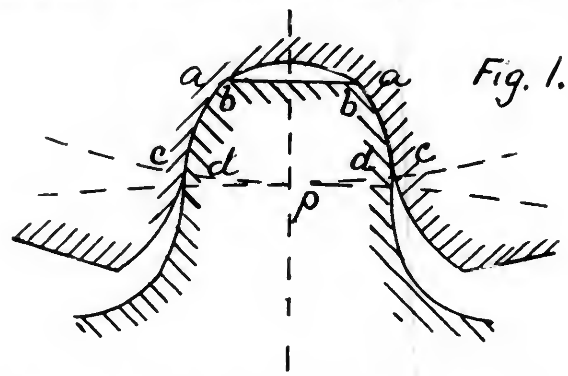


Fig. 1.

Now, as the wheels move in either direction from the position shown in fig. 1, the centers for the arcs $a\ c$ and $b\ d$ must separate, and there cannot be a common normal to these arcs; from which it is evident that the velocity-ratio must vary, and that the continuance of large bearing surfaces is impossible.

On the other hand, if the curve $a\ c$ is not a circular arc, and it really seems to be nothing more nor less than a clearance curve traced by the point b, the velocity-ratio of the engaging wheels must have innumerably different values at the same time, which is absurd, and, in either case, whether the curve $a\ c$ is a circular arc or not, the claim that the teeth fit together on the line of centers as shown, condemns them absolutely.

Such teeth are simply corrugations unworthy to be mentioned among the refinements of modern practice, and the more thoroughly they are weeded out the better.

It is, of course, possible for such gears to run together, but their action is far from perfect, and I know from experience with them something about the intolerable noise that they make while running.

It would be very nice, indeed, if one cutter could be used successfully on all wheels of the same pitch, but when this is done properly, it is very certain that the method used will be such as to cut a different shape for every different number of teeth, and I venture to predict that whatever forms of teeth may be favored by engineers, the hypercycloidal will never find a place among them.

Philadelphia, May 21. WILFRED LEWIS.

THE PRINCIPLES OF RAILROAD LOCATION.

BY PROFESSOR C. D. JAMESON.

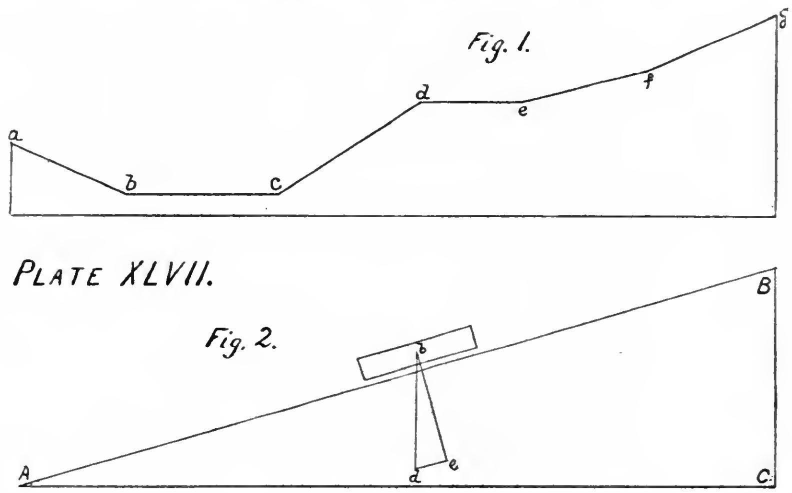
(*Continued from page* 254.)

CHAPTER XXV.

RULING GRADE.

BY the RULING GRADE of a road is meant that grade which limits the length and weight of the train that can be hauled over that road or section. In the case of the ruling grade, it is the rate of grade and the length that should be considered and studied, and not the actual rise in feet.

The ruling grade, however, is not in all cases the steepest grade on the road, for the reason that the steepest grade may either be so short or so located in reference to the preceding grade that heavier trains may be able to surmount it by means of acquired momentum than some other grade of less rate but longer or less fortunately situated. Thus, in Plate XLVII, fig. 1, the rate of the grade *f g* is much less than *c d*, still *f g* would be the ruling grade.



Any train to surmount *c d* would be able to get a run at it down *a b*, and be able to surmount it by means of the momentum thus acquired. In the case of *f g* the approaching grade *e f* would do away with the possibility of acquiring any surplus momentum. Or, to take another case, the steeper grade may be opposed to the lighter traffic, and thus one much less steep, but opposed to the heavier traffic, may become the ruling grade.

But, other things being equal, when the ruling grade is so situated that it can be surmounted by momentum it is practically reduced by the amount that can be gained by this acquired momentum, and the virtual ruling grade as affecting the weight and length of the trains would be the actual grade on the ground, less the grade that could be surmounted solely by the momentum acquired. This subject of virtual grades will be more fully explained farther on, but for the present purposes the ruling grade of a road is the steepest virtual grade, and the effect of this grade as a ruling grade is due to the rate of grade and to its length, while on minor grades, that is, grades that are less than the ruling grade, their bad effect is due, not to the rate of the grade, but to the actual amount of rise and fall. As a basis for the comparison of the cost of running the trains, or the operating expenses of the railroad, we will take the cost per train-mile, that is, the average cost of running the average train one mile, and this has been found to be $1 more or less.

The Train-Mileage of a road would be the sum of the product of the number of trains run by the number of miles run by each. This cost per train-mile, of course, will vary in each particular case, depending upon the alignment and condition of the road, the class and amount of traffic, and the regularity with which it comes to the railroad. That is, whether about an equal amount has to be hauled each month, thus keeping a minimum amount of rolling stock fully occupied, or whether the bulk of the traffic comes with a rush in certain months of the year, so that a large amount of rolling stock is then needed, while comparatively little traffic is done the remainder of the year. Of course, in this latter case the average cost per train-mile would be much greater, if the interest on the investment be taken into account, as it should be.

When the bulk of traffic is in such freight as coal, minerals, slate, or anything with which the cars can be fully loaded, the ratio of the cost per train-mile to the gross earnings per train-mile is much less than in the case of miscellaneous freight, as the ratio of paying to non-paying load hauled is much less. The direction of the traffic—that is, the amount going in either direction over the road—also has a great effect on this ratio.

From these and various other causes too numerous to mention, the cost per train-mile varies in each particular case, but the average for the principal roads of the United States can be fairly taken to be $1 per train-mile. On a road not yet built, it is, of course, extremely difficult to calculate with any degree of exactness what the future cost per train-mile will be, or how many daily trains will be run. By the number of daily trains is meant how many trains run over the road one way in one day, as every train that goes out is supposed to return. The only way is to find out what it is upon a line situated as nearly similar as possible. In cases where changes are to be made in location of a line of road that is already built and in operation, it is comparatively an easy matter to find the exact cost per train-mile, and thus the exact value of the proposed improvements, or rather the maximum amount that can economically be spent upon them.

We have stated that the resistance to the movement of a train upon a straight, level track at an average speed is about 9.3 pounds per ton of weight hauled. Or it may be

found for any speed by the following formula of D. K. Clark's:

$$R = \frac{v^2}{171} + 8$$

R = Resistance in pounds per ton of 2,240 pounds.
v = Speed in miles per hour.
Where R = Resistance in pounds per ton of 2,000 pounds the formula will be:

$$R = \frac{v^2}{200} + 7.3$$

This formula is the one most generally used in this country, and, considering the number of variables which enter into any calculations of this question, probably gives results as correct as many more elaborate ones, and certainly has the advantage of great simplicity and ease of application.

To find the resistance opposed to the movement of a train by a grade we have simply the following problem in mechanics: Given a weight and a certain inclined plane to find the amount of power applied to the weight, parallel to the inclined plane, which will just move the weight, all friction being left out of the question, as this friction is what is overcome in moving a train upon a level track.

In Plate XLVII, fig. 2, let $A\ B\ C$ be the inclined plane and W the weight. Then draw $b\ d$ vertical and equal to the weight, and complete the triangle $d\ e\ b$, making $b\ e$ perpendicular to the plane and $d\ e$ parallel to it. Then will $d\ e$ represent the required force, or the resistance to motion up the incline due to the incline solely. And from similar triangles we have $d\ e = \frac{C\ B \times b\ d}{A\ C}$ or the resistance due to the grade = weight multiplied by the rise of the incline, divided by the length. On railroads the angle of the grade with the horizontal is so slight, even on the steepest grades, that in the above triangle, as applied to grades, $A\ C$ is always taken as equal to $A\ B$.

Taking these two equations we find that a grade of 24.5 ft. to the mile doubles the resistance opposed to the movement of a train that is met with on a level, straight track at a speed of 20 miles an hour. That is, it requires twice as much power to haul a train up a grade one mile long with a vertical rise of 24.5 ft. as it does to haul it on the level, straight track. Now, as we have seen, it is of no consequence what the *rate* of grade is when it is not the *ruling* grade, but simply the actual vertical height that affects the resistance opposed to the movement of a train. We have, in terms of the amount of power developed, a vertical rise of 24.5 ft. equal to one mile of distance. In order to shorten and simplify the calculations we will call it 25 ft., which is probably nearer the correct amount. Therefore each 25 ft. of vertical rise in a railroad, no matter at what rate the rise is made (always provided it is not the ruling grade and is within reasonable limits), requires as much extra power to surmount it at a speed of about 20 miles an hour as would haul the same train one mile on a level, straight track. This is the amount of extra power required; but the increase in the expenses required by the development of this extra power is not in the same proportion as the increase in the power developed. In other

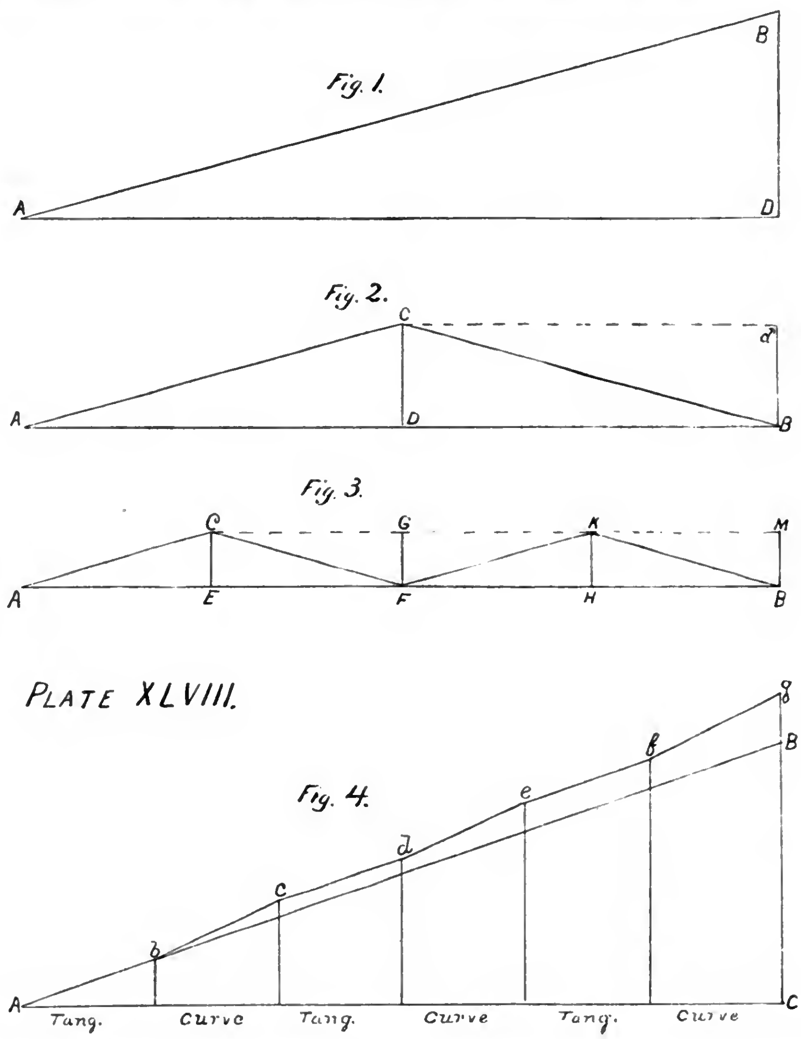


Plate XLVIII.

words, when the amount of power exerted by the locomotive is doubled, the expenses are not doubled, but are only increased in a very slight degree. A careful examination of the data obtained from various roads shows that when the amount of power exerted is doubled the operating expenses are only increased about one-sixth and therefore the number of feet of vertical rise required to double the operating expenses is $25 \times 6 = 150$, or, we may say, each 150 ft. of vertical rise increases the cost of operating by the amount required to move a train one mile on a straight, level track. In other words, 150 ft. of vertical rise and fall is equal to one mile of distance.

By the "operating expenses," as used above, we mean that part of the total operating expenses of the road which is affected by these slight differences in length, and which, we shall see farther on, amounts to about one-half only of the total operating expenses.

In considering the grade of a railroad as affecting the movement of trains, we consider that every train runs the whole length of the road and returns, and therefore passes over every foot of up or down grade twice. Thus, in Plate XLVIII, fig. 2, let $A\ C\ B$ represent the profile of a railroad between A and B. Then any train moving from A to B and return passes up the grade $A\ C$ and down the grade $C\ B$ in going, and up the grade $B\ C$ and down the grade $C\ A$ in returning; thus making the vertical distance through which the train has to be lifted, in making a round trip, equal to $C\ D+B\ d'$; or the total amount of vertical rise and fall in the road is the sum of the vertical rise or fall of each grade considered in one direction only. In Plate XLVIII let figs. 1, 2, and 3 represent the profiles of three different roads of which it is desired to obtain the vertical rise and fall as affecting the movement of trains. Commencing with fig. 1, the total vertical rise and fall equals $B\ D$. In fig. 2 it equals $B\ d' + C\ D$, and in fig. 3 it equals $C\ E+F\ G+H\ K+M\ B$. In this case the total vertical rise and fall of each of these lines would be the same, and this total rise and fall, divided by 150, will give the distance in miles, and fractions of a mile, which must be added to the actual length of the line to give the virtual length of the line in regard to grades, and in terms of the operating expenses; or, in other words, it would cost the same to run the same train at the same speed over a level road whose length was equal to the length of the actual road plus the total number of feet of rise and fall divided by 150, as it would over the actual road with its broken profile. We now know the value in horizontal distance of each foot of vertical rise and fall in a railroad line in terms of the operating expenses, and the next point is to find the value in horizontal distance of each degree of curvature in terms of the operating expenses.

We will assume that the resistance due to curvature varies inversely as the length of the radius, or directly as the number of degrees in the central angle. This, of course, is only correct theoretically, but for making any general rule that shall be approximately correct it is the only basis upon which we can go. It has been ascertained, as near as may be, that a curve one mile long, with a radius of 506 ft., presents a resistance to the movement of a train equal to one mile of straight, level track, or that double the amount of power is required to haul an average train at about 20 miles an hour over one mile of curve, of 506 ft. radius, as upon a straight, level track. A curve one mile long with a radius of only 506 ft. contains 600 degrees of curvature or 600 degrees of central angle. Therefore, in terms of the amount of power developed, 600 degrees of curvature equals one mile of distance. It must always be remembered that all these calculations are made for an average train running at about 20 miles per hour, where the resistance to movement on a straight track is about 9.3 pounds per ton of 2,000. For the reason that the resistance on a straight, level track increases as the square of the velocity the radius of the curve one mile long, which shall double the resistance, varies inversely as this resistance on the straight, level track. Thus, at a speed of 46 miles per hour it would require a curve one mile long with a radius of 253 ft., or 1,200 degrees of curvature, to double the resistance.

But at the rate of speed we have assumed as the average rate—20 miles per hour—600 degrees of curvature are equal to one mile of distance, in terms of the amount of motive power developed. In doubling the amount of motive power, however, as we have already said, we do not double the cost of running the train. The increased amount of operating expenses due to overcoming the resistance encountered on 600 degrees of curvature, or a resistance equal to that encountered on one mile of level, straight track, has been found to be about one-third of the whole operating expenses per train-mile, or about two-thirds the operating expenses that are affected by slight changes in distance. Therefore the number of degrees of curvature which are equal to one mile of straight, level track, in terms of the operating expenses, is $600 \times \frac{3}{2}$, or is equal to 900 degrees of curvature.

The values of the items in the following table are given in terms of the motive power developed or resistance overcome:

Items.	Distance.	Curvature.	Rise and fall.
1 mile	5280 ft.	600 degrees.	25 ft.
1 degree curvature...	8.8 "	1 "	0.041 "
1 ft. rise and fall	211.2 "	24 "	1 "

We know the cost of running an average train one mile. The next question is to examine the items of expense which go to make up this cost of $1 per train-mile, and see how these items are affected by each additional mile run. The items which make up this $1 per train-mile are as follows:

Motive Power.	Oil, Fuel, Waste, Water, Engineer, Fireman, Cleaning, Repairs.
Train expenses.	Train hands, Repairs of cars, Renewals.
Road repairs.	Track, Road-bed, Structures.
General.	Station, Terminal, Taxes, Repairs, Renewals.

These, in general terms, are the items which go to make up the cost per train-mile. It is evident by inspection that very many of these items are not in the slightest degree

affected by slight changes in distance such as we are now considering. The items which are most affected are the repairs to locomotives and cars, fuel and maintenance of way; but even these do not vary directly as the distance, but are only increased about 75 per cent. for each additional train-mile, and this would increase the cost per train-mile about 50 per cent. or 50 cents, so that every train run one extra mile would cost the road 50 cents. Now if there is to be a train each way over the road every day, with the exception of Sundays, and, with the usual number of extras, we may take the total number of trains run over the road each way during one year as 350, or the total number $350 \times 2 = 700$, and for every extra mile these trains are run the increased cost to the road will be $\$0.50 \times 700 = \$350$; or one mile of increase of distance equals \$350 and one foot equals \$0.066 for one daily train each way for one year. This \$350 is the yearly interest on the sum of money that can be economically spent per daily train to save this increase of distance of one mile or one foot. Taking the rate of interest at 6 per cent., \$350 would be the yearly interest on \$5,833.33; this, then, is the amount per daily train that could be spent economically over and above the original cost of construction to shorten the road one mile, and \$0.066 is the annual interest on \$1.10, which is the amount that could be spent economically over and above the original cost of construction to save one foot of distance.

When we say that this amount of money can be economically spent to save this distance, we take into account simply the operating expenses of the road. Of course, in actual practice, the ability of the road to raise this necessary money and the interest which it would have to pay on it during the time of construction would enter largely into the question; but as this is something which has to do solely with the financial stability of the railroad company and the state of the money market at the time the road is being built, it is not a question which enters in any way into our present calculation.

Putting these statements in tabular form, we have the following, the average or normal cost per train-mile being taken, as above, at \$1.

I. Cost per Year per Daily Train of Additional Distance, Grade, or Curvature.

Unit.	Value per year per daily train.	Amount, capitalized at 6 per cent.
1 mile distance.......	\$350.00	\$5,833.33
1 ft. distance........	0.066	1.10
1 degree curvature....	0.39	6.50
1 ft. rise and fall......	2.33	38.33

II. Equivalent Distances, Grades and Curves in Terms of the Operating Expenses.

Items.	Distance.	Curvature.	Rise and fall.
1 mile..............	5,280 ft.	900 degrees.	150 ft.
1 degree curvature...	5.86 "	1 "	.166 "
1 ft. rise and fall.....	35.2 "	6 "	1 "

The operating expenses are calculated per year per daily train.

The following formula is the most simple method of using the above data, in finding the virtual length of a line:

$$V = e + \frac{g}{150} + \frac{c}{900}$$

e = Actual length of line in miles.
V = Virtual length in miles.
g = Rise and fall in feet.
C = Sum of all the central angles.

Then to find the actual amount that can economically be spent on the line with the longest virtual length to make it equal to the other line we have

$$\text{Amount} = \frac{(V - V')\ 35000\ t}{N}$$

where V = Virtual length of first line.
V' = Virtual length of second line.
\$350 = cost per year per daily train.
N = Rate of interest.
t = Number daily trains.

The foregoing results apply to only such changes in length, curves, and grades as would produce a virtual difference in length of from 0 to about 2 miles in 100. For such changes as would produce a difference of from 2 to 10 miles in 100, about 10 or 12 per cent. should be added, and the relative disadvantages of any additions in length, curves and grades increases as the proportional amount of the addition increases, until soon a point is reached where the increase in the operating expenses due to this additional virtual length is directly as the increased length.

CHAPTER XXVI.

COMPENSATION FOR CURVATURE ON GRADES.

If, on a grade composed of curves and tangents, a uniform rate of grade is preserved, the effect upon the movement of trains is the same as if the curves had been removed and tangents of the same length, but an increased rate of grade, substituted for them: Thus, in Plate XLVIII, fig. 4, let *A B* be a uniform grade having the alignment as shown on *A C*. Then the Virtual Grade, or the one which affects the movement of trains, is not the straight line *A B*, but the broken line *A b c d e f g*, the alignment of which is supposed to be a tangent.

That is, whenever a curve occurs upon a grade, the amount of resistance due to the grade is increased by the amount of resistance due to the curve, and in order to preserve a uniformity in the amount of motive power required, or the resistance to be overcome, the rate of grade should be lowered a certain amount on the curves.

What this amount should be we will now consider. We have found that, in terms of the resistance to be overcome, 600 degrees of curvature equal 25 ft. of rise and fall, or 1 degree of curvature equals 0.041 ft. of rise and fall.

Therefore, theoretically, the rate of grade should be reduced 0.041 per cent. per degree of the curves upon it, or, in other words, the rate of grade on curves should be reduced every station of 100 ft. by 0.041 times the degree of curvature, the amount being in feet.

There are, however, several questions upon the consideration of which it is found necessary to reduce the amount of compensation for curvature.

The amount of resistance opposed to the movement of a train by a curve by means of which 600 degrees of curvature is made equal to 25 ft. of rise and fall, is not known to be exact, even for the speed we have assumed for the train. It is only approximately correct for that one speed and not correct for any other.

The resistance due to a curve is very much greater with a very slow train and much less with a faster one. So that, even if our supposition is true under the conditions we have assumed, and we compensate our curves by the coefficient 0.041, it would not give a uniform resistance at any other speed. From this fact we see that the amount of compensation may be changed slightly either way without materially affecting the result.

Between any two points that are fixed and are at different elevations there is a certain amount of unavoidable rise and fall on any railroad line connecting them, and also, usually, a certain amount of curvature. If, therefore, all of these curves which occur upon grades are fully compensated for—that is, the rate of grade reduced on the curves—there will be just this amount of rise and fall *more* to go into the tangents, thereby increasing the rate of grade on them.

Thus, in order to have a uniform Virtual Grade upon a line having a fixed amount of rise and fall, not only must the trains all run at a uniform speed, but the length and degree of each curve must be known and the length of each tangent.

Then from these data a new coefficient of compensation must be calculated for each grade.

In order to obviate these complexities, and arrive at what shall be practically a uniform Virtual Grade, the compensation for Curvature on Grades may be taken generally at 0.03 per cent. per degree of curvature.

(TO BE CONTINUED.)

NOTES ON STEAM HAMMERS.

By C. Chomienne, Engineer.

(Translated from the French, under special arrangement with the Author, by Frederick Hobart.)

(*Continued from page* 257.)

CHAPTER V.

THE FRAMES.

THE frame of the hammer being subjected to great fatigue, especially when it rests directly on the bed-plate, it is important to give it such a form and section as may be best adapted to the work which it is to do and the weight which it is to support.

The best form is that which, for an equal weight, possesses the greatest moment of inertia and gives, in consequence, the maximum resistance. The form which best fulfills this end and which best resists the strains of torsion and bending is the hollow circular column; but in very large hammers the question of putting together the different parts makes a hollow rectangular form favorable, on account of the ease of fitting. Such a form has been adopted at Creusot and in the Steel Works of the Marine for their 80-ton hammers.

These frames have been made in three parts, solidly fastened together by means of bolts and wrought-iron hoops turned and put on hot, in order that should one of the parts break it will be easy to replace it at comparatively small expense and in a short time.

Where the frames are of cast iron we should avoid having parts in bearing together of too great thickness, for it often happens that these parts become detached under the action of shocks.

We should also take pains to have the thickness of section as uniform as possible, especially where the frames are hollow, so that injurious effects from reaction may be reduced to a minimum.

As a general rule, the frame—that is, the supporting frame or legs—should be divided in two parts below, in order to give as much space as possible for handling the forging, and to give room enough to set the anvil, and also at the same time to afford as wide a base as can be given.

We will now pass in review the different forms used for these frames, giving at the same time the names of the builders who have applied them. Sketches of these forms are given as follows:

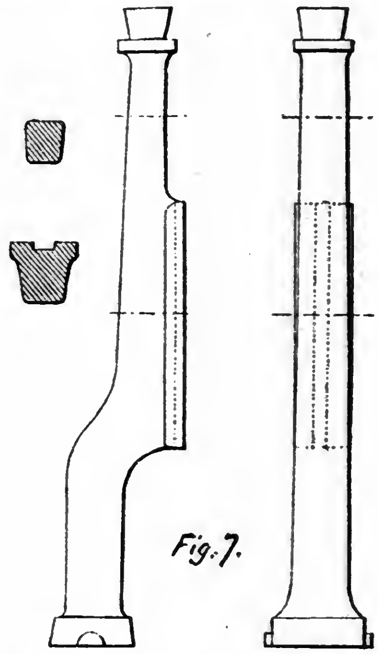


Fig. 7. Creusot; l'Horme; Besseges; hammers from 1 to 4 tons.*

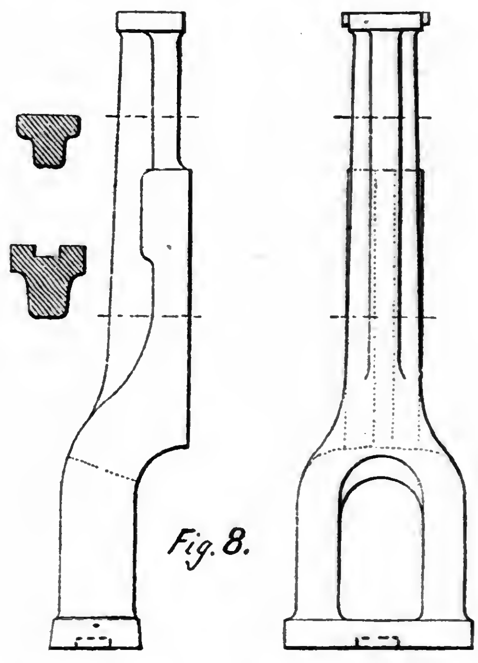


Fig. 8. Creusot; l'Horme; hammers from 2 to 20 tons; also Marrel Brothers, from 2 to 50 tons.

Fig. 9. L'Horme; hammers from 2 to 20 tons.

Fig. 10. Thwaites Brothers; hammers from 2 to 20 tons.

Fig. 11. Brunon; hammers from 1 to 5 tons.

Fig. 12. Nasmyth & Wilson; the Woolwich 35-ton hammer.

* Throughout these articles the metric measures and weights are used. They can readily be transferred, the reader remembering, of course, that 1 meter = 39⅜ in., and 1 kilogramme = 2.204 lbs. The metric ton is 1,000 kilogrammes, or 2,204 lbs.

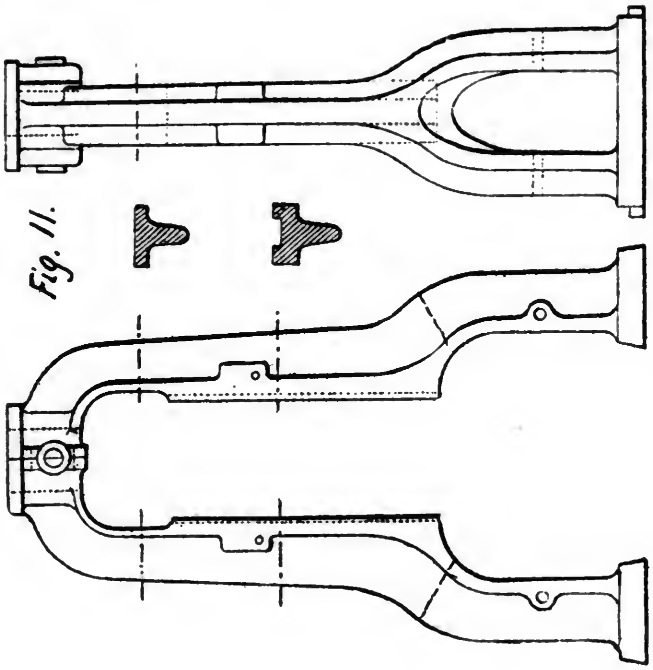


Fig. 11.

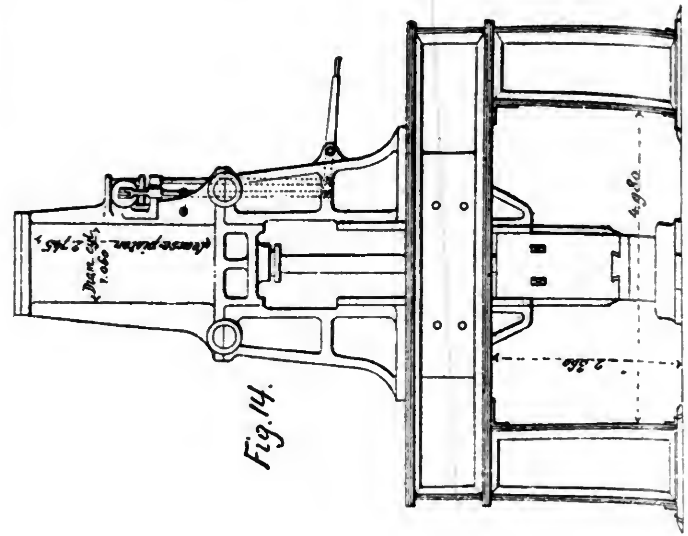


Fig. 14.

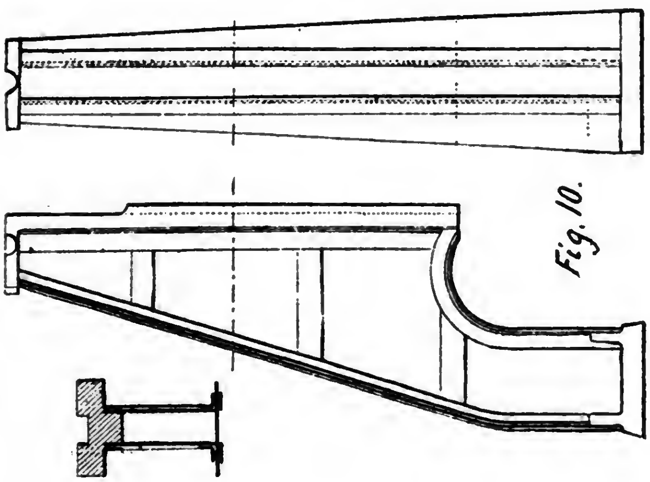


Fig. 10.

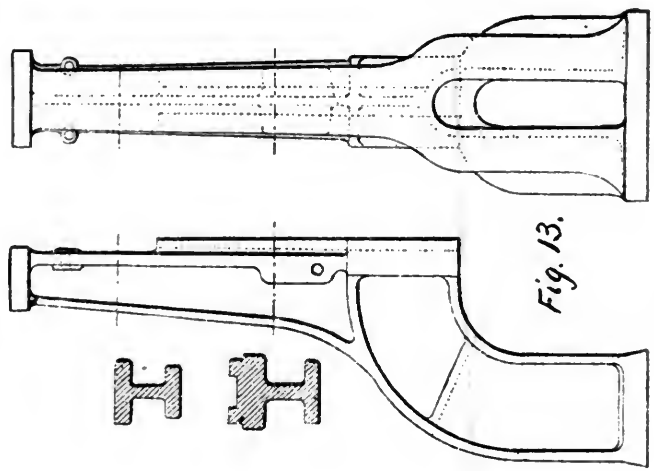


Fig. 13.

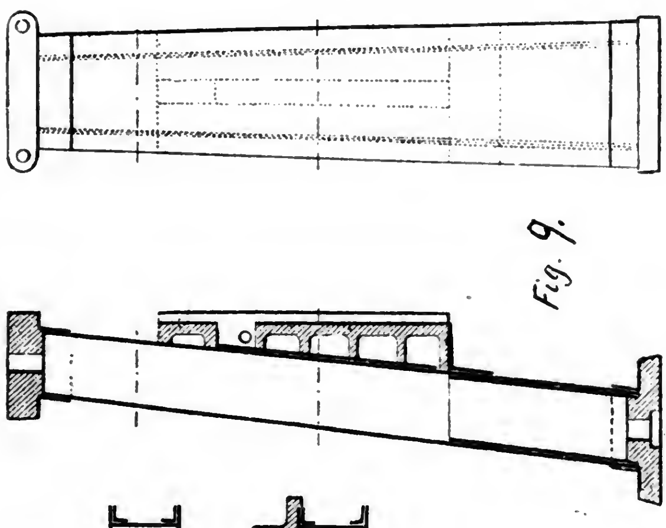


Fig. 9.

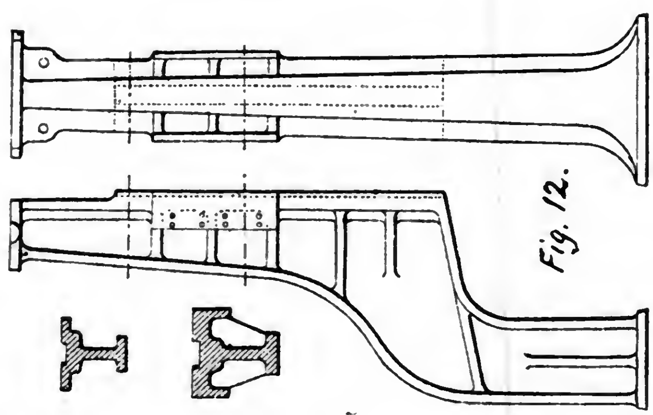


Fig. 12.

Fig. 13. Creusot Works ; hammers from 4 to 20 tons.
Fig. 14. Thwaites Brothers ; hammers from 5 to 15 tons.
Fig. 15. Thwaites Brothers ; light hammers from 5 to 10 tons.
Fig. 16. Thwaites Brothers ; heavy hammers from 5 to 20 tons.
Fig. 17. L'Horme ; a later pattern for hammers from 5 to 20 tons.
Fig. 18. Thwaites Brothers ; pattern used for the 35-ton hammer for Sir William Armstrong at Elswick.
Fig. 19. Pattern used for the 80-ton hammer in the Steel Works of the Marine and the 100-ton hammer of Marrel Brothers at Creusot.

Of several of these forms and sections of frame, especially of those in figs. 12–17, inclusive, we will speak again hereafter, when describing the details of the hammers.

M. Brunon has built a type of hammer (fig. 11) in which the two legs of the frame are united above in such a way as to form a circular recess or socket to receive the steam-chest. This plan has the advantage of dispensing with the upper frame or table, but has so much rigidity that it is necessary to make the section of the legs much heavier than in ordinary cases.

The type shown in fig. 14, which was designed by Thwaites, is in very common use in England.

The frames of the 80-ton hammer of the Steel Works of the Marine are strengthened or re-enforced at a certain height by heavy plates of wrought iron, which add to the solidity and insure the stiffness of the whole.

In the frames of the 100-ton hammer at Creusot there have been added, in addition to these braces below, two others above the slides of smaller dimensions than those below.

The legs or upright portion of the frame are joined to the upper frame or table in several ways.

1. By means of a conical lug which enters, but with considerable play, into the upper frame, which is fixed to the latter by wedges of wood compressed into the openings by means of iron keys. The object of this system is to take up as much as possible the shocks transmitted to the legs, and in consequence to prevent their breakage.

2. The second system consists of the use of bolts and of hoops put on hot, which secure a complete connection of the parts ; this is especially used in the case of independent bed-plates, because then the shocks of which we have heretofore spoken are very much diminished and the chances of breakage are diminished ; an example of this is shown in fig. 8.

We cannot close the description of this part of the hammer without speaking of those hammers with wooden pillars or frames, which are now gradually disappearing, having given place to metallic frames.

This type of hammer was studied out in 1857 for M. Arbel by M. Chalas, who was then Engineer of the Firminy Steel Works. It was especially intended for the manufacture of wrought-iron wheels for locomotives in the work-shops which M. Arbel had just established at Rive-de-Gier. It was necessary in this case to have a wide opening between the legs and much elasticity, the masses to be forged being so large and the blows required so heavy that the cast-iron frames—the only kind then used—did not present sufficient security for this work. M. Chalas conceived the happy idea of replacing them by wooden pillars. In this way great economy was secured, and the time necessary for the construction of the hammer was reduced one-half.

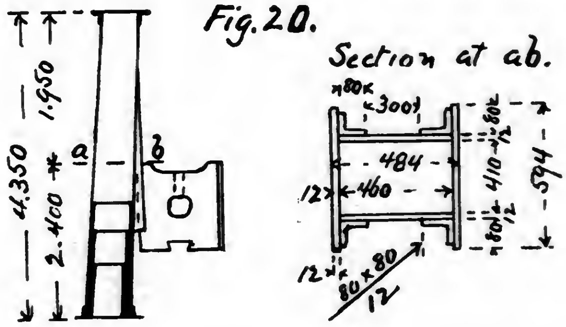
This type of hammer, then, fulfilled all the conditions required for this class of work : solidity, elasticity, and especially cheapness—a matter not to be despised in founding a new industry.

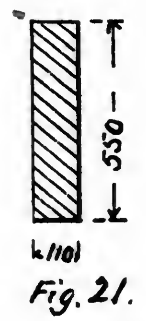
Hammers of this type have been constructed from 5 to 30 tons ; they have rendered excellent service for a number of years, and the necessity of replacing them is still far from being felt.

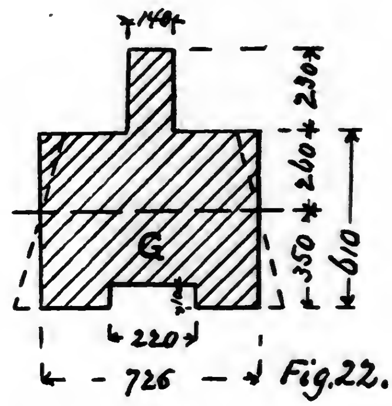
CHAPTER VI.

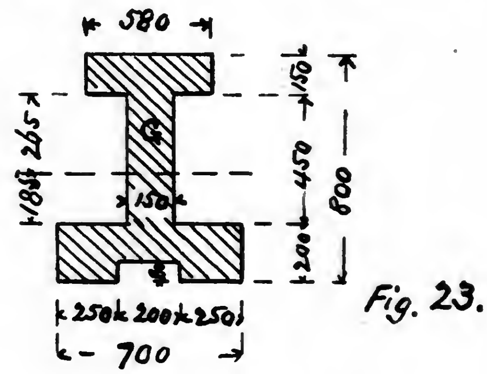
CALCULATIONS FOR THE FRAMES.

The required strength for the frames or uprights can be calculated, if we assume that they rest at their extremities on two points and take the force transmitted by the hammer itself at the end of its fall—that is, at the moment when it strikes the forging. We will here apply this method to four different types of hammers.









1. The Arbel 40-ton hammer (fig. 20). Here we have :

$$\frac{I}{n} = \frac{4.8 \times 59.4^3 + 13.6 \times 45.8^3 + 30 \times 43.4^3 - 46 \times 41^3}{12 \times 29.7},$$

$$\frac{I}{n} = 4,474.$$

The bending moment will be as follows :

$$\frac{P \times 195 \times 240}{435} = 107\ P,$$

$$107\ P = R \times 4,474 = 600 \times 4,474 = 2,684,400,$$

$$P = \frac{2,684,400}{107} = 25,090.$$

The ratio between this load P and the weight of the working parts is, then :

$$\frac{25,090}{40,000} = 0.62725.$$

As there are two pillars, one on each side, this ratio becomes $0.62725 \times 2 = 1.2545$—that is, the two uprights together should be able to support in this place, without experiencing any appreciable bending, a load of $1.2545 \times 40,000 = 50,180$ kilogrammes.

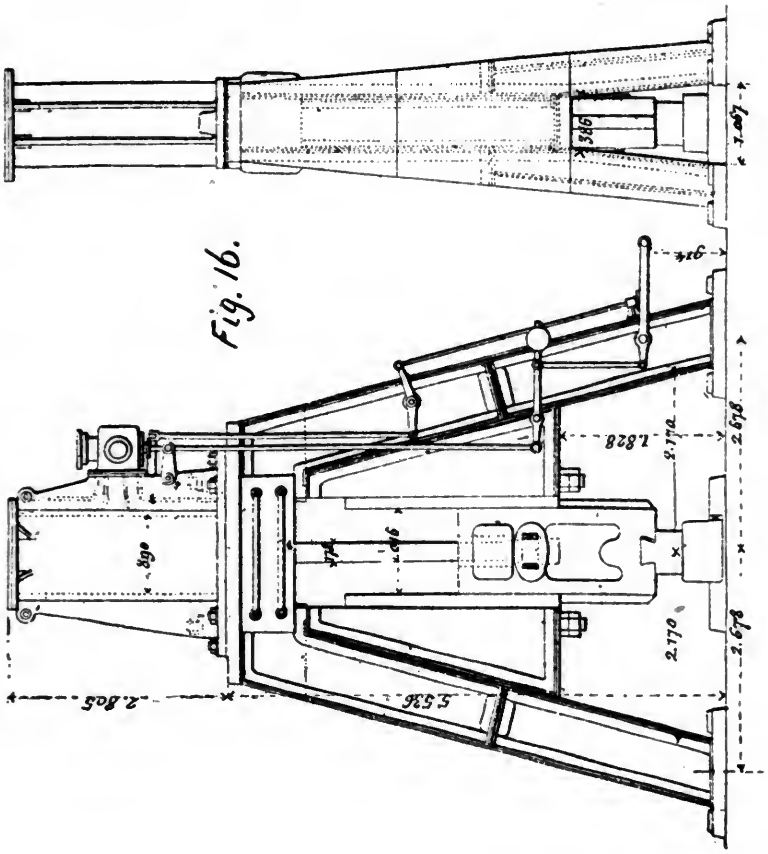


Fig. 16.

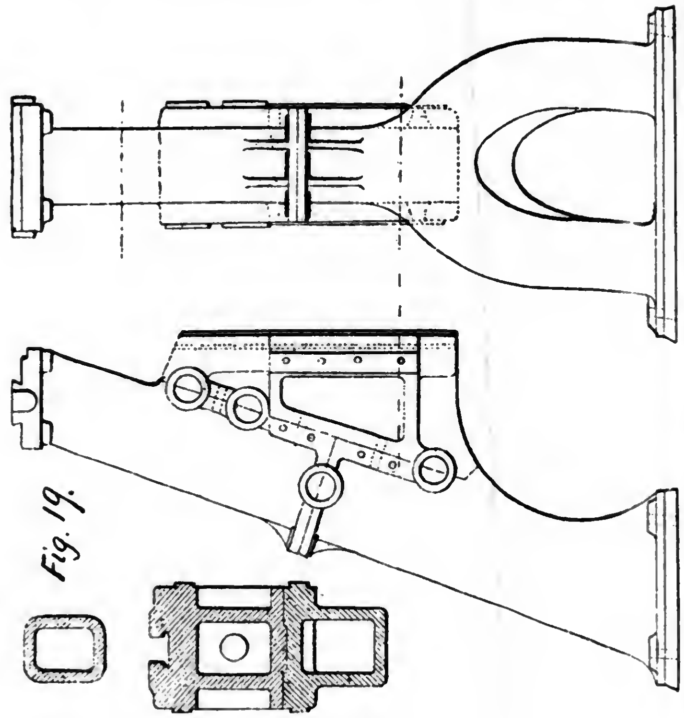


Fig. 19.

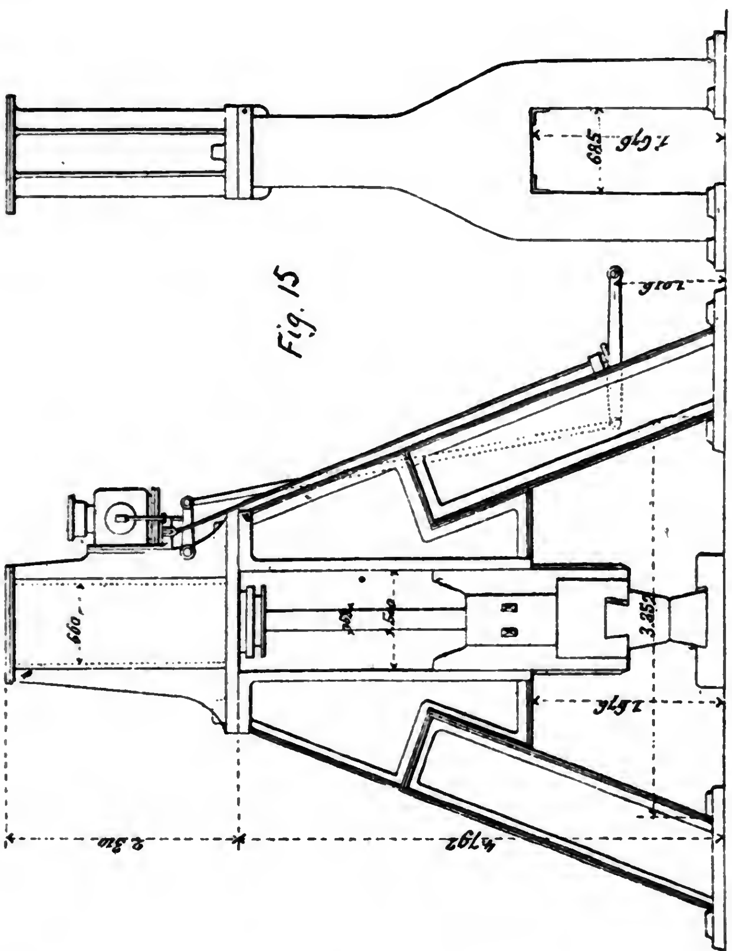


Fig. 15

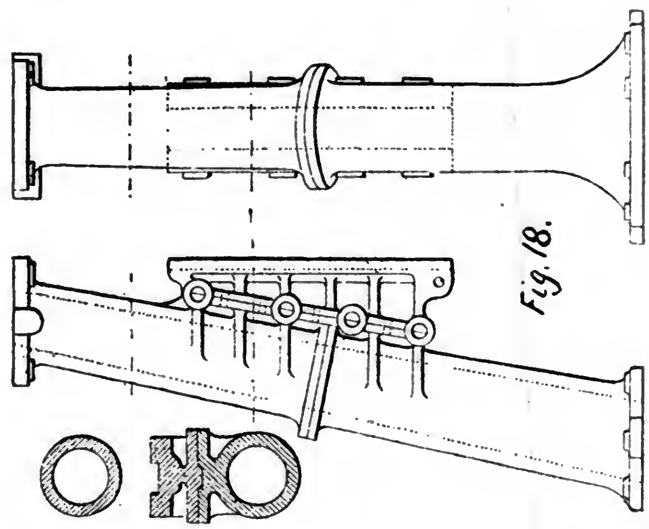


Fig. 18.

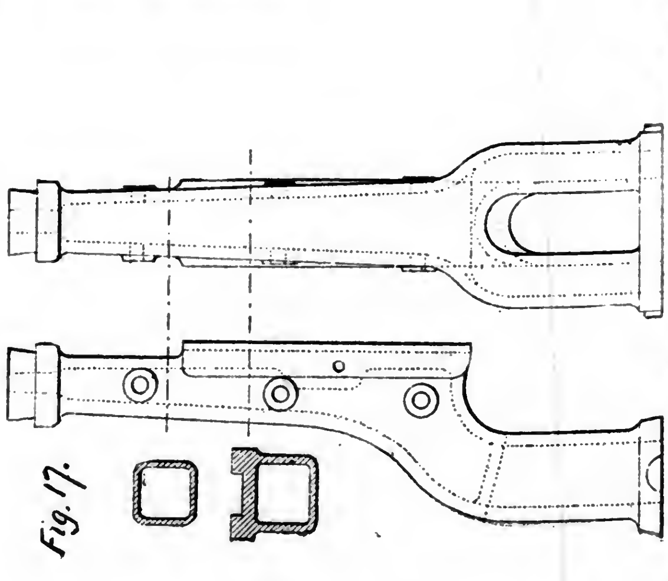


Fig. 17.

2. The Bietrix 15-ton hammer (fig. 21). Here we have:

$$\frac{I}{n} = \frac{11 \times 55^3}{12 \times 27.5} = 5,546.$$

The bending moment is as follows:

$$\frac{P \times 247 \times 210}{457} = 113\,P,$$

$$113\,P = R \times 5,546 = 600 \times 5,546 = 3,267,600,$$

$$P = \frac{3,267,600}{113} = 28,916.$$

The ratio between this load and the weight of the working parts will then be:

$$\frac{28,916}{15,000} = 1.9.$$

For the two pillars of the frame the ratio will then be 3.8.

3. The Creusot 20-ton hammer (fig. 22). Here we have:

$$\frac{I}{n} = \frac{58.5 \times 26^3 + 14 \times 49^3 + 50.5 \times 35^3 + 22 \times 25^3}{3 \times 49} = 44,600.$$

The bending moment is as follows:

$$\frac{P \times 320 \times 280}{600} = 150\,P,$$

$$150\,P = R \times 44,600 = 300 \times 44,600 = 13,380,000,$$

$$P = \frac{13,380,000}{150} = 89,200.$$

The ratio is, therefore:

$$\frac{89,200}{20,000} = 4.46.$$

This ratio is for a single pillar.

4. L'Horme 10-ton hammer (fig. 23). Here we have:

$$\frac{I}{n} = \frac{58 \times 41.5^3 - 43 \times 26.5^3 + 70 \times 38.5^3 - 55 \times 18.5^3 - 20 \times 38.5^3 + 20 \times 30.5^3}{3 \times 41.5}$$

$$\frac{I}{n} = \frac{6,321,486}{124.5} = 50,775.$$

The bending moment is as follows:

$$\frac{P \times 340 \times 280}{620} = 153\,P.$$

$$153\,P = R \times 50,775 = 300 \times 50,775 = 15,232,500,$$

$$P = \frac{15,232,500}{153} = 99,558.$$

The ratio is, therefore:

$$\frac{99,558}{10,000} = 9.96.$$

This ratio also is for a single pillar; it is very high, and shows that the section of the frame is very strong in proportion to the power of the hammer.

These four examples show us that—the resistance being 6 kilogrammes for wrought iron and 3 kilogrammes for cast iron—the ratio between the load P and the weight of the working parts of the hammer should never be less than 1.25 for hammers with wrought-iron frames and 4.00 for those with cast-iron pillars. For small hammers—up to 3 tons—this ratio should be increased to a figure as high as 15.

We believe that the future tendency will be toward frames of wrought iron, composed of hollow rectangular columns built up of plates and angles, rather than toward cast-iron frames, in which breakages are common, especially when they rest directly on the bed-plate. Besides this, the cost of cast-iron frames is greater than that of the wrought-iron, if we take into account the great difference in weight and the lower resistance of the cast iron. Small hammers up to 2 or 3 tons alone should be built with cast-iron frames, on account of the lighter section, the simplicity of form, and the ease of construction, which is important in these lighter tools.

In the United States, however, the practice is still to use cast iron for the pillars, even for hammers of considerable size. This is in great part due to the fact that in this country we have better iron at our disposal, and can make much stronger castings than those commonly turned out in Europe. Moreover, the cost of wrought-iron work is relatively much higher here.

Wrought-iron frames or pillars composed of hollow riveted girders are much to be preferred to solid forged columns. They have the advantages of lower cost and much greater strength for an equal weight. They have also the advantage that they can be fitted and erected much more readily than the heavy forged frames.

CHAPTER VII.

THE UPPER FRAME OR CYLINDER-PLATE.

The upper frame unites the legs or pillars of the supporting frame together. Its form varies according to the shape of the steam-chest and the method by which it is fixed to the legs. In the 80-ton Creusot hammer this upper frame serves at the same time as a steam-chest and as a support for the cylinder.

Many English builders, such as Thwaites and Massey, do away altogether with the steam-chest and the frame, as

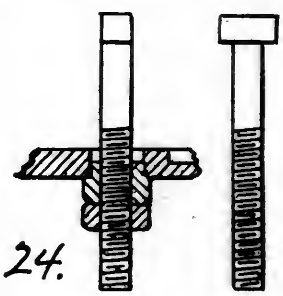


Fig. 24.

shown in figs. 14, 15, and 16. The cylinder bears directly on the legs, and is fixed to them by bolts and hoops.

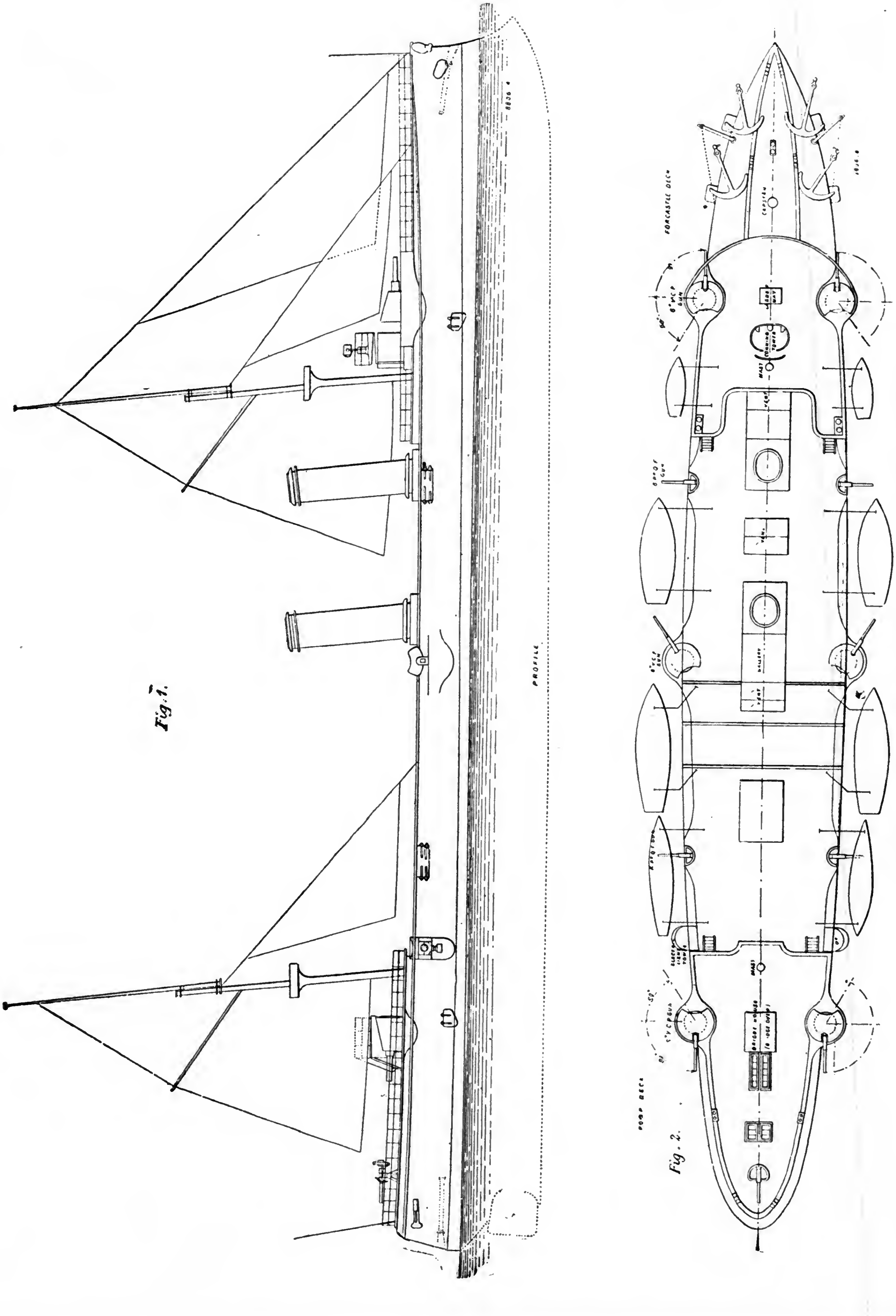
The bolts which hold the flanges of the stuffing-box should be so made that they can be easily replaced; a T-headed bolt similar to that shown in fig. 24 is very convenient for this purpose.

We may note here that it is well, in order to prevent the stripping of the thread on the lower parts of these bolts, to make the holes in the flange of the stuffing-box through which the bolts pass large enough to permit the base of the nut to enter (as shown in fig. 24). These nuts can then be screwed up tight without any risk of injuring the thread, which is not the case in ordinary bolts, which are often injured by the unequal tightening of the nuts.

The stuffing-box is made in two parts, and is bored out in such a way as to permit the lower end of the piston-rod to pass through it freely.

The upper frame should have a section sufficiently large to resist the shocks which are transmitted to it. It must support, through the steam-chest, the total pressure exercised upon the piston.

In order to limit the stroke of the hammer and to prevent the shocks which might be caused by the carelessness or want of skill of the hammersmith, there are placed below the frame and on the face of the lugs on the upper part of the hammer two blocks of oak, which by their elasticity may absorb a part of the shocks transmitted, and often prevent the breakage of the stuffing-box and sometimes of the frame. This arrangement is much better than one which is often employed, and of which we have before spoken, which is to force two round pins of oak into the holes left in the lugs of the hammer, as the portion which is above at the moment of the stroke is the least sound; moreover, the section of the pins which can be forced into these holes is generally small, so that they are rapidly crushed in service.



FAST CRUISER "MAGICIENNE," FOR THE BRITISH NAVY.

Built by the Fairfield Shipbuilding and Engineering Co., Glasgow, Scotland.

CHAPTER VIII.

THE CYLINDERS.

The cylinder does not require very particular mention, except to say that certain English and Belgian builders are accustomed to cast the cylinder and steam-chest in one piece.

The diameter of the cylinder should be calculated with reference to the minimum pressure of steam used in the shop, and the section of the piston-rod should be deducted, as the pressure of the steam is not, of course, exercised upon that part of the piston where the rod enters.

With very large hammers it is not unusual, after a heat which has been continued 30 minutes or over, to see the pressure fall from 5 to 3 kilos.; it is necessary that at such a time the diameter of the cylinder shall be so great that the hammer can be still worked at the reduced pressure.

Moreover, it is necessary to consider that it may be sometimes very useful, if we can increase the power of a hammer without making a new cylinder for it. This is a case which was recently presented at Creusot, where the weight of the large hammer was raised from 80 to 100 tons without changing the cylinder.

In this case, in order that the stroke should not be diminished, the hammer having been lengthened 1 meter, it was necessary to add between the pillars or legs and the upper frame two brackets 1 meter in length and to increase the diameter of the piston-rod from 360 to 420 millimeters.

In some very powerful hammers, which have usually a long stroke, the cylinder is made in two parts and the flanges are re-enforced by vertical ribs, which are tapered off gradually above the flange.

The face of the steam-chest on which the cylinder rests should be turned up slightly convex, in order that any water which may condense in the cylinder may run off at the outside, and may not pass into the stuffing-box, where it would probably corrode the metal and finally drip down upon the hammer.

(TO BE CONTINUED.)

The New English Fast Cruisers.

(From the London *Engineering*.)

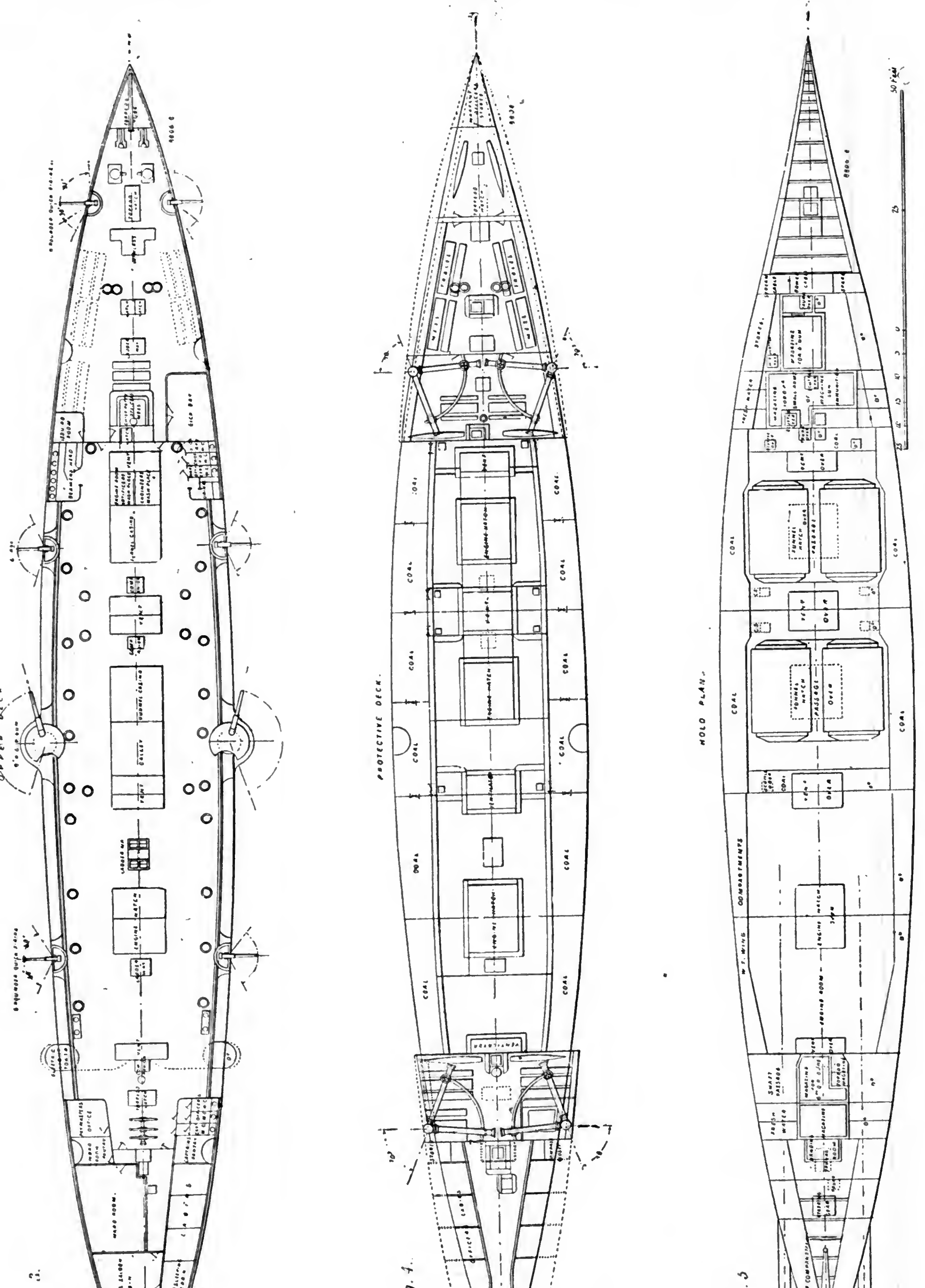
THE most important vessels included in the programme of the British Admiralty for 1887-1888, were the five protective cruisers now building at Chatham and Portsmouth and on the Clyde, which include many new features in design and construction, and are a further development of a type of war ship, which, although not yet tried in actual warfare, is looked upon favorably by some naval constructors as a valuable auxiliary to the much more powerful and fully equipped ironclad. The five vessels are named *Medea*, *Medusa*, *Melpomene*, *Magicienne* and *Marathon*. The first two are building at Chatham, the *Melpomene* at Portsmouth, and the two last-named in the shipbuilding yard of the Fairfield Shipbuilding & Engineering Company at Govan, Glasgow.

The vessels are similar in dimensions and in their internal arrangements, but the constructive material and engines are different. The *Medea* and *Medusa* are being built entirely of steel, and their displacement will be 2,800 tons. Their engines are placed vertically, with inverted cylinders. In the case of the other three ships, the steel hulls are sheathed with wood and copper to enable them to remain afloat for long periods without having their bottoms fouled and their speed consequently reduced. This sheathing, of course, increases the displacement to within a few tons of 3,000 tons, and their speed may consequently be reduced by about ¼ knot to about 19¾ knots. Even in view of this slight loss of speed and the additional first cost which such an arrangement involves, the change of plan is acceptable, as it will give the cruisers an additional advantage over ordinary vessels, rendering them able to lie in coaling or other stations for a long period, and to be afterward available for a speedy voyage of action without the necessity of entering a dock in which to have the hull cleaned. With the exceptions indicated the five cruisers are alike.

Of the vessels, the *Marathon* is the furthest advanced, and was the first to be launched from the Fairfield yard, the launch of the *Magicienne* taking place later. Like the other ships of the same type, the *Marathon* is 265 ft. long, 41 ft. beam, and about 24 ft. deep, and the displacement will be between 2,950 and 3,000 tons. She was first built of steel in the usual manner and afterwards sheathed with two thicknesses of teak, making a total thickness of 6 in. The inside layer was attached to the steel hull by iron bolts, and the outside one by bolts of gun-metal. The bottom of the ship is further covered with sheets of copper nailed to the teak. The ram, stem, stern, and rudder-posts, and the brackets for supporting the twin screws by which the ship is propelled, are all cast in solid bronze, these castings together weighing for each ship about 45 tons. The form is similar to those generally used in the construction of Government vessels, the stern-casting being, of course, the more intricate. The whole structure is built and strengthened in such a way as to offer the maximum resistance to artillery.

For protection the vessel depends principally on a 2-in. steel deck extending from stem to stern. This deck resembles the back of a turtle, having a declivity at bow and stern and along the sides of the vessel. The top level of this deck—in the center of the ship—is practically level with the water line, and the declination all round makes the connection of the deck with the side of the ship at a point about 5 ft. from the water line. Under this deck are placed the propelling engines and the machinery for working the ship—all the vital parts of the mechanism—as well as the magazines. The coal bunkers are arranged above and below the deck in that part of the vessel where the engines, boilers, etc., are situated, so that additional protection may thus be secured. The vessel has a double bottom on the cellular principle for carrying water ballast. The interior of the hull is divided by bulkheads into 10 main water-tight compartments, two of which are occupied by engines, and two others by boilers. These four have no doorways between the spaces, but in some of the other bulkheads there have been fitted doors workable either at the door or from the top deck. In addition, these main compartments are subdivided especially above the protective deck, there being in all close on 270 water-tight spaces.

The machinery for the *Magicienne* and *Marathon*—the vessels building at Fairfield—has been constructed by Messrs. R. & W. Hawthorn, Leslie & Co., Limited, St. Peter's Works, Newcastle-on-Tyne. The engines for each of the cruisers are of the twin-screw horizontal surface-condensing type, each engine being placed in a separate water-tight compartment. The diameters of the cylinders are: High-pressure, 34½ in.; intermediate, 51 in., and low-pressure, 76½ in., the stroke of piston being 36 in. The engines are designed to run at 150 revolutions per minute, and the horse power to be indicated is 9,000. The total condensing surface is 11,850 square feet. The air pumps are driven from the pistons of the main engines. Separate feed engines, both main and auxiliary, are provided for feeding the boilers. There are also separate bilge and fan engines, feed-heaters, distillers of the latest double-distilling type, and separate surface-condenser with its air and circulating pump adapted for condensing all the steam from the auxiliary engines, dynamos for supplying the electricity to light the ship, air compressors, capstans, windlasses, etc. Steam is supplied to the main and all auxiliary engines in each ship from four double-ended cylindrical boilers, two in each of the compartments set apart for them. These boilers have in all 24 corrugated furnaces, with a grate surface of 456 square feet, and a heating surface of 14,070 square feet. They are constructed to work to a pressure of 155 lbs. per square inch. There are four stokeholds, which are arranged for working under forced draft on the "closed stokehold system" now universal in the Navy. The air is supplied to the furnaces when under forced draft by eight double-sided fans driven direct by high-speed engines. The machinery throughout is as light as it possibly can be consistently with due strength to withstand the strains which come



FAST CRUISER "MAGICIENNE," FOR THE BRITISH NAVY.

Built by the Fairfield Shipbuilding and Engineering Co., Glasgow, Scotland.

upon it when under forced draft and full speed. The shafting is entirely of steel, and is hollow; all rods are of the best mild steel, and the bed-plates, piston, piston valves, cylinder covers, and most of the valve gear are of cast steel. The stern tubes and propellers are of gun-metal. The framework of the rudder is of solid bronze, sheathed with thick gun-metal plates, and filled in solid with pitch pine. Particular care has been taken to provide against the steering gear being incapacitated. The rudder, which is on the balance principle now adopted in many war ships, can be worked by hand or steam gear placed under the protective deck, or from the bridge or pilot tower.

The armament of the ship consists of six 6-in. (5-ton) breechloading rifle guns, on central-pivot Vavasseur mountings, two placed forward, two aft, and one each on starboard and port side amidships; ten 6-pounder quick-firing guns, three light guns under 15 cwt., and several machine guns. Six torpedo tubes are to be fitted on board, all under cover, one forward, another aft, and two on each broadside.

Accommodation has been provided for a crew of about 300 men all told. The officers are accommodated under the poop aft, and the "tars" forward. There are the usual cabins, ward, gun and mess-rooms.

The external appearance of the vessel will be smart. She has two funnels and two masts. These will only have fore-and-aft steadying sails, the vessels being solely dependent upon their steam power and twin screws to drive them along at the high speed of 19¾ or 20 knots. The military tops are to be dispensed with in these vessels. This many will regard as a step in the right direction, as the "crow's nest" has been looked upon often as the most likely spot at which the enemy would aim.

The estimated cost of the hull of each of these vessels, as given in the Navy Estimates, is £64,790; of the machinery at £50,824, while the total cost, including gun mountings, torpedo gear, and stores, is calculated to be £136,752.

The vessels were designed under the supervision of Mr. W. H. White, Director of Naval Construction. They were commenced in August last year, and those building at Fairfield are expected to be completed in November next, so that the time occupied in their construction will be between 15 and 16 months. This, however, must not be regarded as the "record" of the Fairfield Company in speedy shipbuilding. One of the principals in the yard is reported to have said, when interviewed by a representative of a London shipping journal: "With our resources in this yard we could turn out a war vessel in three months from date of order if necessary, and there are other builders that could do nearly the same."

UNITED STATES NAVAL PROGRESS.

We give below several notes in relation to naval matters of interest which have occurred during the past month.

NEW SHIPS.

The appropriation bill reported to the House of Representatives by the Naval Committee authorizes the expenditure of $6,000,000 for the increase of the Navy, $4,000,000 being for construction of ships and $2,000,000 for armament. The bill provides for the construction of four ships; two unarmored cruisers of about 3,000 tons displacement, each to have a guaranteed speed of 19 knots; one unarmored cruiser of 5,300 tons, with a guaranteed speed of 20 knots, and one armored ship of about 7,500 tons displacement, with no guarantee of speed, but planned to make not less than 17 knots. One of the four must be built in a navy yard, and all may be built in such yards if the President is satisfied that none of the bids made by contractors is reasonable.

The acts of March 3, 1885, August 3, 1886, and March 3, 1887, authorized the construction of ships to cost in the aggregate a trifle less than $20,000,000. The amount thus far appropriated for these ships is $8,315,000. This is exclusive of about $7,000,000 appropriated for guns and armor in 1886 and 1887, of which about $4,000,000 will be required to pay the contracts made with the Bethlehem Iron Works a year ago, leaving $3,000,000 to the credit of the Secretary.

Leaving out the double-turreted monitors and the four cruisers, there has been spent on the ships ordered in the past three years $2,403,935, and the balance on hand for them is $3,453,848. The double-turreted monitor *Miantonomoh* will be finished in four months. The large cruiser *Baltimore* will be launched this month and finished in six months. The *Vesuvius* will be ready for delivery on September 1. The double-turreted monitor *Puritan* has had her dock trial and has been accepted, but her armor has not been put on. The double-turreted monitor *Amphitrite* is ready for her steam trial, which will occur soon. The machinery for the double-turreted monitor *Monadnock* is in process of construction at Mare Island Navy Yard, from plans prepared in the Navy Department. Three years ago some of the forgings for the 6-in. guns for the Navy had to be imported from England, and all the forgings for the larger guns had to be brought from abroad. Now the forgings for 8-in. guns are made here, and the contract of last year with the Bethlehem Iron Works will make the United States independent of England, even in the case of forgings for the largest guns projected and for the heaviest steel shafting.

The stern-post of the cruiser *San Francisco*, which is to be built by the Union Iron Works in San Francisco, has been successfully cast, and the keel is now being laid.

The Herreshoff Manufacturing Company at Bristol, R. I., has begun work on the new torpedo-boat. This boat will be 138 ft. long, and will have twin screws, with engines capable of working up to 1,800 H.P. The contract speed is 25 knots an hour, and the builders hope to attain 28 knots. The boat will be entirely of steel.

The bids for steel to be used in building the armored cruiser *Maine*, at the New York Navy Yard, were recently opened at the Navy Department, and were as follows:

For steel plates:
- Carnegie, Phipps & Co., Pittsburgh, $89,779. (Accepted.)
- Chester Rolling Mill, Chester, Pa., $114,240.
- Linden Steel Company, Pittsburgh, $120,422.

For steel shapes:
- Carnegie, Phipps & Co., Pittsburgh, $35,986. (Accepted.)

For steel rivets:
- Carnegie, Phipps & Co., Pittsburgh, $9,737. (Accepted.)
- Oliver Brothers, Pittsburgh, $10,584.

For steel castings:
- Pittsburgh Steel Casting Company, Pittsburgh, Pa., $50,176.
- Midvale Steel Company, Nicetown, Pa., $56,448.
- Standard Steel Casting Company, Thurlow, Pa., 18 cents per pound.

NEW GUNS.

Some recent firings at Sandy Hook with the Army 12-in. breech-loading steel mortar for long range tests have given highly satisfactory results. With a charge of 80 lbs. powder and 630 lbs. shell a range of six miles and 135 yards was obtained.

The two 8-in. breech-loading steel guns built by the West Point Foundry for the *Chicago* have been completed and shipped to the proving grounds at Annapolis for test.

The 10-in. steel breech-loading rifled gun designed for the iron-clad *Miantonomoh*, and the first steel gun of this caliber completed by the Navy, has been finally adjusted upon its hydraulic carriage at the Annapolis Proving Grounds, and fired to test the working of the carriage and breech mechanism. These worked easily and accurately, and the gun is now in a condition to carry on experiments for determining the proper grade of powder with which to conduct the statutory tests.

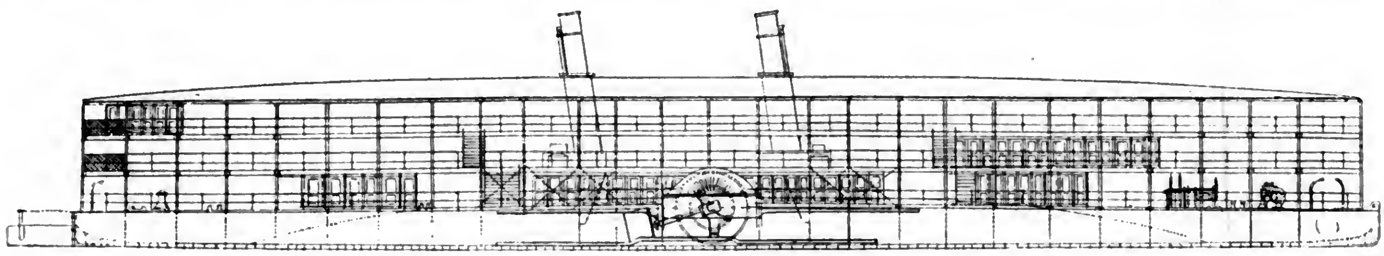
Work at the Naval Ordnance Yard, Washington, is very brisk just now. Work on the breech plug to replace the one destroyed some weeks ago, belonging to the 10-in. gun, is making satisfactory progress, and, if no further accidents happen, the gun for which it is being made will be completed and ready for the proving butts at Annapolis within a month or two. On the new ordnance building in

course of construction considerable progress has been made in the erection of outer walls and piers for supports, but it is not likely that the building will be ready for occupancy before some time next spring. An immense amount of work is in progress on gun carriages and fittings for the batteries of the new cruisers now on the stocks.

The new 53-ton gun recently completed at the South Boston Iron Works is shortly to be tested at Sandy Hook under Government supervision. The gun is of the French type, and is a 12-in., breech-loading, cast-iron rifle, hooped and tubed with steel. It is 30 ft. long. The standard of the trial is 500 rounds, using an 800-lbs. projectile and a charge of 265 lbs. of powder. At the South Boston Works two built-up steel rifles are also in partial construction. These have 8-in. bores, and are entirely of steel. Two 8-in. pneumatic gun carriages for rifle use are also in progress, as well as four 10-in. carriages of a smaller type for use on the monitor *Terror*.

A River Steamer of English Design.

In the Exhibition at Glasgow there is a large collection of drawings and models shown by the leading shipbuilding firms in Great Britain. This collection is especially large, as might be expected, from the firms whose yards are located on the Clyde. As an example of the methods adopted by British shipbuilders to overcome the difficulties of river navigation, we take from the London *Engineer* the accompanying description of a steamer designed and built by Denny & Brothers, of Dumbarton, Scotland, for service on the Irrawaddy River, in Burmah, where at certain seasons the navigation is much impeded by low water and bars in the river, very similar to the obstructions found in many of the western and southern rivers.



STEAMBOAT "THOOREAH," FOR THE IRRAWADDY RIVER, BURMAH.

Built by Denny & Brothers, Dumbarton, Scotland.

The paddle steamer *Thooreah* is represented by a full model, which is shown in our illustration. This is a very interesting exhibit, from the fact that the depth of the hull is so small when compared with the enormous superstructure erected thereon. She is of steel, her dimensions being 260 ft., by 34 ft., by 9 ft. deep amidships, tapering to 7 ft. 6 in. at the extremities, and she is owned by the Irrawaddy Flotilla Company. Above the main deck, and supported on light tubular stanchions, there are two other decks, and above these again is a galvanized iron roof. She has been employed successfully both as a tug and a passenger steamer. Her spacious decks give enormous accommodation for native passengers, who travel about on the rivers in great numbers. The method adopted on the Irrawaddy for towing barges is peculiar to Indian and Burmese rivers. The barges, instead of being towed astern, are lashed one on each side of the tug, and it is a peculiar sight to see a flotilla consisting of a steamer and her two barges moving up or down the river, the whole mass being nearly as broad as it is long. The problems involved in the construction of a steamer of such great length and small depth of hull proper are of much difficulty, and are solved only by making the high superstructures co operate with the body of the vessel as one huge yet light girder. Longitudinal strength is, too, largely obtained by means of double fore-and-aft bulkheads, extending nearly the entire length of the steamer. Owing to the great difficulties encountered in the navigation of the Burmese rivers, especially in the dry seasons, the draft of these vessels is sometimes limited to as little as 3½ ft., and although carrying so much top hamper, they are able to travel at a speed of 12½ knots. Messrs. Denny seem to have overcome all the difficulties involved in Eastern river navigation, and turn out some dozens of these steamers and barges every year.

Testing Armor-Plates.

(From the London *Times*, May 21.)

The experiments with armor-plates were resumed on board the *Nettle*, at Portsmouth, on Saturday, in the presence of Admiral Hopkins, Superintendent of the Dockyard, Captain Douglas, R.A., of the Ordnance Committee, and Captain Domville, of the *Excellent*, who conducted the firing. The previous experiments were made with compound, or steel-faced, armor, such as is now exclusively used for the protection of British war ships, the competing systems of manufacture being what are known as the Wilson and Ellis patents. A 10-in. plate by Messrs. Cammell & Co., Sheffield, exhibited most extraordinary endurance and impenetrability. Though attacked by the new 6-in. breechloader with chilled and solid steel projectiles, it completely resisted perforation at 30 ft., and was little the worse, so far as the integrity of the defense was concerned, after having sustained the blows of five rounds in quick succession. On Saturday the experiments entered upon their second phase, the object being to determine the comparative resisting value of solid steel plates. Several of the great naval powers have adopted steel armor, and even in England, notwithstanding the experience derived from experiments conducted at Spezia, Amager, and elsewhere, naval officers have brought pressure to bear upon the Government with a view of securing the introduction of homogeneous steel plates.

Before venturing, however, to abandon a system of defense which, from the combination of toughness and hardness in the composite material, had withstood the preliminary ordeals very satisfactorily, the Admiralty determined to ascertain the respective merits of the two descriptions of armor by a series of tests under identical conditions. The competition is limited to English firms, and from the behavior of the plate which was subjected to experiment on Saturday there is every probability that our native manufacturers will be able to more than hold their own against those of either France or Germany. The difficulty which attends steel armor is that if made too hard it stars and cracks through under the blows of guns of comparatively light natures, and that when subjected to continuous punishment the plates become so disintegrated that the fragments are only held in position by means of the bolts; and that when, on the contrary, the metal is of too mild a nature, they permit the projectiles to penetrate without breaking them up or materially altering their form.

The plate tested on Saturday was manufactured by Messrs. Cammell & Co., and was forged under their new hydraulic press, which is capable of exerting a pressure of 5,000 tons. In its way it was quite as remarkable as the compound plate which broke up all the shot, both steel and chilled, directed against it. It measured 8 ft. by 6 ft.,

and was of a thickness of 10 in. The composition of the steel is a trade secret, but its flexibility was such that it passed through the ordeal under fire without splintering or falling in pieces like the Creusot plates. Five shots were discharged against it from the 6-in. gun at a 30 ft. range. Two were chilled Palliser projectiles, while the remainder were Hartzel solid forged steel shot. The charge was 42 lbs., the muzzle velocity 1,920 ft. per second, and the muzzle energy 2,556 foot-tons. The chilled shot were entirely broken up, but the indents in the plate were deeper than in the case of compound armor. The steel projectiles were pointed diagonally across the face of the plate from the bottom right corner to the top left corner, the difference in the inclination of arm having an important effect upon the ballistic value of the various rounds. The first shot fired at the normal penetrated the plate, the base being about 5 in. below the surface. The second shot, fired at an inclination of 8°, buried itself in the target with the exception of 2½ in.; while the third and last round, fired at a deviation of 16° from the normal, protruded about 7 in. from the face. None of these projectiles were broken up, but plugged themselves into the softer nature of the plate, where they remained firmly fixed.

The armor-plate itself at the end of the experiment, though cracked in places, retained its position on the backing, and was in a fair state of preservation. Though the shot discharged point-blank at the target penetrated the plate, none succeeded in getting through, but were arrested and held firmly in the grip of the metal. In actual war the possibility of a normal hit is so remote a contingency that it need scarcely be taken into consideration. It is as yet too soon to speak with any certainty as to the superiority of one system over the other; but it is evident that with steel as with compound armor the Sheffield firm has more than kept pace with the Continental manufacturers.

NOTES ON THE SEWERAGE OF CITIES.

(Translated from paper of M. Daniel E. Mayer, Engineer, in the *Annales des Ponts et Chaussées.*)

(*Continued from page* 259.)

IV.—GENERAL ARRANGEMENT OF A SYSTEM OF SEWERS.

In most cities there are old sewers which have been built on the lines of the greatest fall of the surface, in order to carry waste water to the river by the shortest route. Later, when the pollution of the river waters in their passage through the city has become intolerable, the idea has been conceived of building a collecting sewer along the bank of the river to gather water from the transverse sewers and to take it to some point below the city. This second step in the work of sanitation may be considered a definite one, leading the way to a very wide future, in cities like Munich, Vienna and Buda-Pesth, where the river passing through the city has, even in times of low water, a great volume or an extremely rapid current, and where there are no large collections of people below or near the city.

It may be noted here, however, that the municipal administrations of the three cities which we have just mentioned have taken care to make a place in their programme of sanitary work for the future use of the sewage for the irrigation of farm lands.

It happens more frequently, however, that the conditions cited above—a river having a great volume of water or a very rapid flow—are not fulfilled, and the purification of the sewage becomes a necessity.

In this case, however, the concentration of all the waste water upon some point in the valley below the city is not absolutely indispensable. This is the case in Berlin, which is situated on a level plain, and where an original solution of the problem, known as the radial system, was adopted, in which the sewers run from the center of the city to different points selected on the outskirts, and at each of these points there is established pumping machinery which distributes the water through a system of irrigating channels to farms in the neighborhood.

We do not, however, insist upon this system, which, though excellent for the peculiar location of Berlin, would not be applicable in an uneven country, nor to a smaller city. The purification of the sewage waters and their use for irrigation generally require motive power and complicated machinery, and there are very few cities whose importance justifies the establishment of more than one plant of this description.

We must then consider the plan of concentration of sewage at a single point as a normal programme, and the local conditions generally indicate that this point should be below the city. If the bulk of the population and of the buildings are upon a slope which descends with a well marked fall to the river bank, the main collecting sewer must be placed in the immediate vicinity of the river.

But if—a case which frequently happens—the city is divided into two parts, on one side a rapid slope followed by a nearly level valley, there will be an advantage in placing the main collecting sewer at the foot of the slope, in order to avoid the necessity of carrying all the water from that slope through the flat valley; and frequently the subsoil will be much more favorable for the construction of

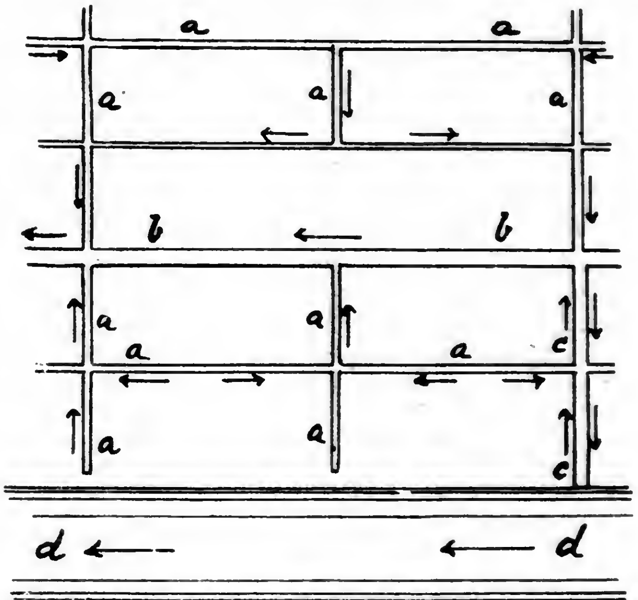


Fig. 1.

subterranean works at the foot of the hill than in the immediate vicinity of the river.

It is only necessary to place the collecting sewer so low that the districts on the banks of the river can discharge their foul waters into it. In order that the sewers of these low districts shall have sufficient fall it will generally be necessary to start them at a point very near the surface. This may be somewhat inconvenient for the purpose of drainage of low land, but, as we have already had occasion to remark, buildings placed too low—that is, on land naturally swampy, or which is subject to overflow—are from this fact burdened with natural drawbacks from which the community is not bound to relieve them, so that the consideration of providing for such cases should not be permitted to modify the general arrangement to any extent.

In order to fix and represent these ideas, we have shown in the accompanying sketch, marked fig. 1, the outline of the arrangement of a system of sewers. In this sketch *a a a a* are ordinary sewers; *b b b* the main or general collecting sewer; *c c* is a branch sewer, which can be used either as an ordinary sewer, or, on occasion, for the discharge of rain water directly into the river; *d d* is the river.

The sewers of the higher part of the city should be able to carry the great volume of rain water of which we have spoken heretofore. But if these sewers, or partial collectors, have a heavy fall, and serve only an area of which one of the dimensions—the width—can be chosen, they

can be arranged in such a way that comparatively small dimensions will be sufficient.

If the main sewer is so arranged that the overflow from very heavy rains can be diverted into the river by means of the auxiliary sewers, it will be necessary to make it only sufficiently large to carry off the surplus water from an average rain. However, in view of the comparatively light fall of the valley it will be generally necessary to make it a work of considerable dimensions.

Frequently the sewers between the river and the main collecting sewer will have a fall less than that of the sewers leading from the higher ground, but greater than that of the main sewer, and as they will not be charged with the overflow from unusual rains (which can be turned directly into the river), small dimensions will be sufficient for them, as for those in the upper districts.

We are now to consider the forms which are best to be given to these sewers, whether small or large, and the best method of dividing among them the fall or slope which is at our disposal.

V.—ARRANGEMENT AND PROFILE OF SEWERS.

We are often called upon in discussing the problem of sewers to treat it in such a way as to hold the balance between two opposing interests: one in favor of the reduction of expenses, which naturally desires works of small size, and another which very often advocates the building of great and imposing works. This apparent contradiction proceeds from an imperfect conception of the qualities which the channels provided to carry off the foul waters should have from a proper point of view. The end to be attained is not to make sewers which can be easily cleaned out by hand, because, even if this is easy, it will be necessary to pay heavily for them. The real object is to make sewers in which hand-work will not be required; that is, in which there shall be no obstructions or deposits. That this object can be attained has been proved by experience in several cities of England and Germany, and we cannot do better than to cite as an example the following extract from a report which the Engineer Lindley made on the sewerage of Frankfort-on-the-Main, where 20 per cent. of the sewers are pipe sewers and more than 50 per cent. are brick of only 0.093 meter (3 ft.) in height:

"The cleaning out of the sewers has been done exclusively by the use of water, requiring only a superintendent and five workmen. Many sections of sewers keep themselves clear; in others it is necessary to flush them periodically in order to wash away the mineral and other deposits. This cleaning service costs about 10,000 francs yearly for the 143 kilometers of the system."

It is not necessary to believe that these excellent results required a very great consumption of water, because, at the time when the lines quoted were written, the City of Frankfort had at its disposal a volume of water less than the 150 liters per inhabitant per day which we have heretofore noted as normal.

This example is not a solitary one, and it is found from experience that in a city where the land is not unusually flat, and where the consumption of water per inhabitant per day approaches the figure of 150 liters, a well arranged system of sewers can keep itself clean. It is only necessary, in order to secure this end, that the precautions, of which we have before spoken, should be taken to prevent the introduction of solid bodies into the sewers.

As, in spite of these precautions, the water sometimes holds solid matter in suspension, it will be necessary to arrange the sewers so that the swiftness of the current will not fall below a certain rate.

The English Engineer, Baldwin Latham, in an excellent paper on this question, fixes, from a large number of facts and experiments, upon 0.062 meter (2 ft.) as a speed below which we should not fall if we wish to avoid deposits in the sewers.

M. Humblot estimates that a speed of 0.090 meter (3 ft.) is insufficient to carry off sand, but that mud and slime will be put in motion under a current of 0.030 meter (1 ft.)

It is, moreover, evident that this object of avoiding deposits will be better attained if the average current of the whole system is greater than that named.

These considerations will lead us, then, to determine the dimensions of the sewers with a view of obtaining the maximum speed of current possible; and, as this maximum for a given duty corresponds to a minimum section of sewer, it will be seen that the best interests of the work are not opposed to but are absolutely identical with economy in the first cost of the system.

This disposed of, we have to study the practical formula for the flow of water:

$$\frac{M}{X} I = b\, u^2$$

In this formula M is the liquid section, or section of the current of water, in meters; X is the perimeter of the current; I is the fall per kilometer; u is the minimum swiftness of the flow per second; b is an empirical coefficient.

We may call Q the quantity of water (in cubic meters) which flows or passes per second.

If the sewer is semicircular the maximum value of u will correspond with the case when the diameter, D, of the passage, for a given value of Q, is so chosen that the semicircle may be filled; hence we have:

$$U = 0.70 \left(\frac{Q\, I^2}{b^2}\right)^{\frac{1}{5}}$$

$$D = 2 \left(\frac{b\, Q^2}{I}\right)^{\frac{1}{5}}$$

If the passage is rectangular, the maximum value of u will correspond to the case where the width, l, of the passage, for a given value of Q, is so chosen that the height of the water shall be equal to $\frac{1}{2}\, l$; hence we have:

$$U = 0.66 \left(\frac{Q\, I^2}{b}\right)^{\frac{1}{5}}$$

$$l = 1.74 \left(\frac{b\, Q^2}{I}\right)^{\frac{1}{5}}$$

There is another form of conduit, hardly applicable practically to city sewers, but theoretically interesting; it is that of a right-angled triangle. This form is the only one in which $\frac{u^5}{Q\, I^2}$, as given in the practical formula, does not depend on Q; in fact, whatever may be the value of Q, we find:

$$\frac{u^5}{Q\, I^2} = \frac{1}{8\, b}$$

The relation here is the same as that which obtains with the rectangular conduit, when we assume the width of that conduit to be so determined from the value of Q as to give u its maximum value.

There are several remarks to be made on these formulæ.

In the first place, we see that the old Latin and French proverbs, "Too much is better than too little," and, "He who can do the greater can do the less," are not applicable to sewer conduits. There is a size of conduit which corresponds, for each duty, to a maximum swiftness of flow; but if the conduits are made too large it is at the expense of the swiftness and velocity of the flow.

This has been proved in Paris, where, for reasons already explained, it has been necessary to make very large passages and to use a radius of 0.50 meter in streets where the ordinary discharge is small. The thread of water spreading itself over too large a surface looses its swiftness and produces troublesome deposits. An easy way to overcome this is found by making a sewer within a sewer—that is to say, a small conduit within the large passage-way. The author, while in the municipal service at Paris, designed, with the Engineer-in-Chief, M. Durand-Claye, a sewer of this kind, and this type is now being generally applied to all the secondary passages.

The formulæ which give the diameter or the width of the conduit contain b, with the exponent $\frac{1}{5}$. For an error, e, in the value of b the relative error in calculating the value of l or D will be only $\frac{1}{5}\, e$.

According to the experiments of M. Bazin, the value of b depends on $\frac{M}{X}$, and, where the walls of the conduit are moderately smooth, is as follows :

$$\left(\frac{l}{4} \text{ or } \frac{D}{4}\right) = \frac{M}{X} = 0.500 \qquad b = 0.2166$$
$$\text{"} \quad \text{"} \quad \text{"} = 0.250 \qquad \text{"} = 0.2432$$
$$\text{"} \quad \text{"} \quad \text{"} = 0.125 \qquad \text{"} = 0.2964$$
$$\text{"} \quad \text{"} \quad \text{"} = 0.100 \qquad \text{"} = 0.3233$$
$$\text{"} \quad \text{"} \quad \text{"} = 0.075 \qquad \text{"} = 0.3667$$
$$\text{"} \quad \text{"} \quad \text{"} = 0.050 \qquad \text{"} = 0.4567$$

The coefficient 0.33, uniformly assumed by Belgrand, thus represents an average value too high for very large sewers and too low for very small ones, but sufficiently exact in the great majority of cases, so far as concerns the determination of l or D.

If we substitute this value ($b = 0.33$) in the preceding formulæ, they become :

$$\text{Semicircular conduit} \begin{cases} U = 1.094\,(Q\,I^2)^{\frac{1}{5}} \\ D = 1.600\left(\frac{Q^2}{I}\right)^{\frac{1}{5}} \end{cases}$$

$$\text{Rectangular conduit} \begin{cases} U = 1.021\,(Q\,I^2)^{\frac{1}{5}} \\ l = 1.410\left(\frac{Q^2}{I}\right)^{\frac{1}{5}} \end{cases}$$

In determining the size of sewers we should see that the value of $Q\,I^2$ (Q being the ordinary duty) should be as great as possible, and that sewers of the same class should preserve a certain uniformity. It is also true that, for the general or main collecting sewer, we should not seek to distribute equally over its length the entire fall from the starting point to the final discharge, but to give more fall to the upper portions of it, because they receive less water.

In order that the condition that u should be greater than 0.062 should be well filled, it is sufficient that $Q\,I^2$ should be greater than 0.100, and this requirement is generally satisfied unless the local conditions are extremely unfavorable.

There is one consideration which may modify the very simple arrangement shown in the sketch above, and this is the necessity of keeping up the fall of the water throughout a system of sewers. It may, in fact, happen that even in the higher part of the system a street running parallel to the direction of the valley may have a very slight fall and may receive very little water. In this case it might be useful, in order to give a proper value to $Q\,I^2$, to cause the water coming from a higher sewer to pass through this street in the direction of the greatest fall of the land, and, in consequence, to break the direct flow of the waters of the latter sewer.

This change in the direction of the current of a sewer will be accompanied by a loss of speed, but the inconvenience arising from this will be much diminished if we take care to bring one sewer into the other at a proper angle or by a circular curve.

(TO BE CONTINUED.)

Electric Lighting of Cars in England.

(From the London *Electrical Review.*)

It would appear that the applicability of the electric light to the illumination of our railway trains is now in a fair way to be thoroughly tested. Trains on the London, Brighton & South Coast line have, for some time past, been lighted by the electric current ; and, now for some months also, have trains on the Metropolitan Great Northern system been similarly illuminated. But all these trains are trains *en bloc—i.e.*, trains which run to and fro on their journey without being broken up. The lighting of these trains has been accomplished by means of a dynamo and accumulators placed in the guard's van. The dynamo is driven from the wheels of the van, and an electrical or mechanical governor completes or breaks the circuit between the dynamo and the accumulators according to the speed of the train. Provision is also made for the regulation of the current according to the direction in which the train is traveling, so that there may be no reversals in charging the batteries.

To purely local trains this system is possibly applicable, but inasmuch as it involves enveloping any portion of the train which may be disconnected from that portion in which the accumulators and dynamo are placed in darkness, should such a mishap at night-time occur, it cannot be regarded as wholly reliable. Still, the system has been useful, and has done good work in that it has, so far, served to prove not only the excellence of the light for the purpose, but afforded considerable experience in the application of accumulators, life of lamps, etc. In fact, what has been done has been the accomplishment of a certain stage on the road. We have learned that secondary batteries may be used for the purpose ; that the motion of the train and the usage to which the batteries have necessarily to be subjected have not proved their unfitness for the work. We have also learned that the vibration of the train does not materially interfere with the life of the carbon filament—that if the lamp is properly fixed and judiciously worked its life may be regarded as equal to that of a lamp employed for illuminating our rooms. These are all stages on the road toward the final application to railway demands.

What these demands are will, we understand, shortly be placed to the test by one of the principal lines. The Midland, a company which has often stood in the van of improvement, and as often advanced the accommodation and interests of the great traveling public, is, we hear, about to fit up two trains upon such a basis as will embrace practically every point of interest to which the question may apply. Each carriage is to carry its own lighting power. The light is to be under the control of the guard, who is to be able to turn it on or off. Should any part of the train or any vehicle become detached the light is to become illuminant, while the storage of the current is to be sufficient to insure a light in each vehicle for several hours. This means that the secondary batteries will, instead of being, as in previous trials, placed all together in the guard's van, be distributed throughout the train, each vehicle having an equal proportion, sufficient to sustain the lamps provided for its illumination for a given period. In accomplishing this there will, of course, be no difficulty ; but it will involve greater expenditure on the part of the railway company. There is, however, no other way of effecting the required result, and which no doubt is a most desirable one, the provision of independent lighting power for each vehicle. The batteries thus distributed will be charged by a dynamo placed in the guard's van, driven from the wheels of the vehicle. This will involve the employment of somewhat heavy cables throughout the train, for it is probable that very low currents will be employed in order to reduce the number of cells, although there is very much to be said in the other direction. Here will probably transpire one of the main difficulties to be contended with—viz., a good and reliable coupling capable of carrying the amount of current required—possibly some 60 ampères.

Broadly these are the principles which will, it is understood, be attempted, and which, if attended with success, will at once, no doubt, establish the applicability of the electric light to railway locomotion—a result which will be received by all railway travelers with delight, for nothing can be much more miserable on a long journey than the wretched lights with which our railway carriages are at present, for the main part, illuminated.

It is understood that the experiment will extend over several months, and that the entire working to which a railway train may be subjected will be carried out. This will comprise "slip" coaches as well as the ordinary making and breaking up of the train at points on the journey ; certain of the vehicles being detached to accomplish the remainder of the allotted journey at certain points, apart from that portion of the train in which the dynamo is placed. The trial will thus be of the most exhaustive character.

We understand that negotiations are also pending for lighting a portion of the stock of a northern company, but upon what principle has not transpired. The fact is, however, apparent, that railway companies are seeking to im-

prove the lighting of their trains, and are looking to the electric light to aid them in their efforts. We believe they will have no cause to regret their resolve. We are quite of opinion that with proper management large economies will attend the introduction of this form of light for railway train lighting. If successful in its application two important and highly satisfactory results will be accomplished: the companies will provide for the public an agreeable and popular form of light, and, at the same time, effect a considerable saving on their existing cost for lighting.

NATIONAL RAILROAD REPORTS.

On June 1 the Interstate Commerce Commission issued an important circular addressed to "all carriers engaged in interstate commerce." This circular is as follows:

The Interstate Commerce Commission desires to call your attention to the subject of the Annual Reports, which are provided for by Section 20 of the Act to Regulate Commerce, as follows:

Sec. 20. That the Commission is hereby authorized to require annual reports from all common carriers subject to the provisions of this act, to fix the time and prescribe the manner in which such reports shall be made, and to require from such carriers specific answers to all questions upon which the Commission may need information. Such annual reports shall show in detail the amount of capital stock issued, the amounts paid therefor, and the manner of payment for the same; the dividends paid, the surplus fund, if any, and the number of stockholders; the funded and floating debts and the interest paid thereon; the cost and value of the carrier's property, franchises, and equipment; the number of employés and the salaries paid each class; the amounts expended for improvements each year, how expended, and the character of such improvements; the earnings and receipts from each branch of business and from all sources; the operating and other expenses: the balances of profit and loss; and a complete exhibit of the financial operations of the carrier each year, including an annual balance-sheet. Such reports shall also contain such information in relation to rates or regulations concerning fares or freights, or agreements, arrangements, or contracts with other common carriers, as the Commission may require; and the said Commission may, within its discretion, for the purpose of enabling it the better to carry out the purposes of this act, prescribe (if in the opinion of the Commission it is practicable to prescribe such uniformity and methods of keeping accounts) a period of time within which all common carriers subject to the provisions of this act shall have, as near as may be, a uniform system of accounts, and the manner in which such accounts shall be kept.

Said Act applies to all common carriers engaged in such transportation of passengers or property as is described in its first section. Very many railroads, which are located wholly within one State, are, nevertheless, very largely engaged in interstate commerce. In fact, under the present methods of conducting joint traffic, nearly every road, however short its line, unites in making through rates, under which it issues and receives tickets or bills of lading, in connection with roads in other States, upon which passengers and freight are transported across State boundaries; the revenues of every such road are derived, to a greater or less extent, from the traffic which is regulated by the provisions of the Interstate Commerce Law.

The information which this law authorizes the Commission to require is very general in its nature and scope. It embraces "a complete exhibit of the financial operations" of the carriers each year, as well as all the details which are enumerated in the section quoted above.

It is apparent that it was the purpose of Congress to inaugurate an annual collection of statistics, which should faithfully present the entire transactions of every railroad in the United States for the preceding year; and that the information so obtained should be authoritative and trustworthy.

Such returns, when arranged upon a uniform system and presented under official sanction, cannot fail to be of great interest and value to all carriers, as well as to Congress and the public.

As to many of the matters enumerated, the value will be greatly lessened if the statistics are incomplete. No attempt has heretofore been made to provide for a general collection of railroad facts and figures, except through unofficial methods and by the Census Bureau. For obvious reasons these methods have not given satisfactory results, in comparison with the annual statistics which are obtained in other countries. A new plan has been established, under the supervision of official authority, in the expectation that a permanent and uniform system of reports, both as to date of compilation and form of statement, may soon prevail throughout the land.

In preparing the blank return, which is now in press and about to be issued, every effort has been made to reduce it to a simple, intelligible, and practicable form. If the efforts of this Commission shall be seconded by the Railroad Companies and by the various State Railroad Commissioners, it is entirely feasible to speedily bring all railroad accounts throughout the United States upon a uniform basis, and to present them annually to the country and to the world in a manner worthy of the importance of the subject.

Up to this time the suggestions and requests of the Commission have been most satisfactorily met by both the State Commissions and the carriers. A very free interchange of views has been had with the accounting officers, in the first place before the preparation of an experimental form, and afterward in its revision and correction. The blank about to be issued is believed to be the closest approach to a universally satisfactory system which has yet been made in this country. It is also confidently believed that there is no information asked which the carriers cannot readily furnish and will not cheerfully give, and it is hoped that every detail of inquiry has a permanent value.

The Commission, therefore, without ruling definitely at the present time upon the question of what railroad companies may or may not be required by the act to file the returns in question, will furnish blanks to *every* railroad company in the United States, whatever its situation or relative importance, in the belief that every carrier will cheerfully and promptly contribute its share toward the attainment of a complete and trustworthy annual exhibit of the entire railroad system of our country.

ACCIDENTS ON BRITISH RAILROADS.

The report of the Board of Trade on Railroad Accidents for the year 1887 has recently been issued. The summary showing the total number of accidents to persons on British railroads from all causes during the year is as follows:

Accidents to trains, rolling-stock, permanent way, etc., caused the death of 33 persons, and injury to 647—viz.:

	1887.		1886.	
	Killed.	Injured.	Killed.	Injured.
Passengers and others	25	538	8	615
Servants of companies	8	109	4	81
Total	33	647	12	696

During the year 1887 there were reported 31 collisions between passenger trains or parts of passenger trains, by which 25 passengers were killed and 244 passengers and 14 servants were injured; 42 collisions between passenger trains and goods or mineral trains, etc., by which 1 servant was killed and 187 passengers and 47 servants were injured; 16 collisions between goods trains or parts of goods trains, by which 2 servants were killed, 6 cattle dealers and drovers and 24 servants were injured; two cases of trains coming in contact with projections from other trains traveling on parallel lines by which 6 passengers were injured; 49 cases of passenger trains or parts of passenger trains leaving the rails, by which 1 servant was killed and 20 passengers and 10 servants were injured; nine cases of goods trains or parts of goods trains, engines, etc., leaving the rails, by which 3 servants were killed and 1 was injured; two cases of trains traveling in the wrong direction through points, by which 1 servant was injured; 23 cases of trains running into stations or sidings at too high speed, by which 1 servant was killed and 52 passengers and 5 servants were injured; 116 cases of trains running

over cattle (during the year 25 horses, 3 ponies, 55 beasts and cows, 108 sheep, 7 donkeys, 1 goat and 2 pigs were run over and killed) or other obstructions on the line, by which 3 servants were injured; 4 failures of engine machinery, by which 2 servants were injured; 1 failure of brake apparatus, by which 15 passengers were injured; 3 failures of couplings, by which 1 passenger and 1 servant were injured; 5 slips in cuttings or embankments, by which 1 passenger and 1 servant were injured; and two other accidents, by which 6 passengers were injured.

The following cases were also reported, but they involved no personal injury: 47 cases of trains running through gates at level crossings; 1 case of the bursting of the dome of an engine; 767 failures of tires; 1 failure of a wheel; 281 failures of axles; 1 failure of a chain used in working an incline; 1 failure of a bridge; 1 failure of a tunnel; 244 broken rails; 8 cases of flooding of the permanent way; 8 fires in trains; and 9 fires at stations or involving injury to bridges or viaducts.

Of the 767 tires which failed, 15 were engine-tires, 14 were tender-tires, 8 were carriage-tires, 21 were van-tires, and 709 were wagon-tires; of the wagons 515 belonged to owners other than the railway companies; 651 tires were made of iron and 116 of steel; 21 of the tires were fastened to their wheels by Gibson's patent method, and 2 by Beattie's, none of which left their wheels when they failed; 30 by Mansell's, one of which left its wheel when it failed; 35 tires broke at rivet-holes, 8 at the weld, 125 in the solid, and 599 split longitudinally or bulged.

Of the 281 axles which failed, 161 were engine axles, 145 crank or driving, and 16 leading or trailing; 20 were tender axles, 3 were carriage axles, 94 were wagon axles, and 3 were salt-van axles; 53 wagons, including the salt-vans, belonged to owners other than the railway companies. Of the 145 crank or driving axles, 82 were made of iron and 63 of steel. The average mileage of 80 crank or driving axles made of iron was 216,412 miles, and of 63 crank or driving axles made of steel, 235,649 miles.

Of the 244 rails which broke, 96 were double-headed, 147 were single-headed, and 1 was of the bridge pattern; of the double-headed rails, 52 had been turned; 26 rails were made of iron and 218 of steel.

Of the 472 persons killed and 977 injured in this division, 96 of the killed and 759 of the injured were passengers. Of the latter, 19 were killed and 61 were injured by falling between carriages and platforms—viz., 8 killed and 36 injured when getting into, and 12 killed and 467 injured when alighting from trains; 37 were killed and 20 injured while passing over the line at stations; 72 were injured of the closing of the carriage doors; 2 were killed and 23 injured by falling out of carriages during the traveling of trains; and 24 killed and 60 injured from other causes. There were 63 persons killed and 35 injured while passing over railways at level crossings—viz., 29 killed and 28 injured at public level crossings, 21 killed and 7 injured at occupation crossings, and 13 killed at foot crossings. There were 203 persons killed and 114 injured when trespassing on the railways; and of other persons not specifically classed, but mostly private people having business on the companies' premises, 40 were killed and 69 injured.

During the year there were 414 servants of companies or contractors reported as having been killed and 1,966 injured, in addition to those suffering from train accidents. Of these 26 were killed and 232 injured while coupling or uncoupling vehicles; 4 were killed and 29 injured by coming in contact while riding on vehicles during shunting with other vehicles, etc., standing on adjacent lines; 16 were injured while passing over or standing under buffers during shunting; 20 were killed and 135 injured in getting on or off, or by falling off engines, wagons, etc., during shunting; 7 were killed and 123 injured while breaking, spragging, or chocking wheels; 14 were killed and 75 injured while attending to ground points, marshaling trains, etc.; 8 were killed and 187 injured while moving vehicles by capstans, turntables, props, etc., during shunting operations; 19 were killed and 76 injured by falling off engines, vans, etc., during the traveling of trains; 6 were killed and 148 injured while attending to or by failure of machinery, etc., of engines in steam; 99 were killed and 97 were injured while working on the permanent way, sidings, etc.; 3 were killed and 2 injured while attending to level-crossing gates; 93 were killed and 127 injured while walking, crossing, or standing on the line of duty; 9 were killed and 55 injured by being caught between trains and platforms, walls, etc.; 37 were killed and 36 injured while walking, etc., on the line on the way home or to work; and 7 were killed and 99 injured from various other causes.

Altogether, the number of persons killed and injured on railways in the United Kingdom in the course of public traffic, during the year ending December 31, 1887, as reported to the Board of Trade, was as follows:

	Killed.	Injured.
Passengers:		
From accidents to trains, rolling-stock, permanent way, etc	25	538
By accidents from other causes	96	759
Servants of companies or contractors:		
From accidents to trains, rolling-stock, permanent way, etc	8	109
By accidents from other causes	414	1,966
Persons passing over railways at level crossings	63	35
Trespassers (including suicides)	273	114
Other persons not coming in above classification	40	69
Total	919	3 590

In addition to the above, the railway companies have reported to the Board of Trade, in pursuance of the Sixth Section of the Regulation of Railways Act, 1871, the following accidents which occurred upon their premises, but in which the movement of vehicles used exclusively upon railways was not concerned—namely: 3 passengers killed and 139 injured while ascending or descending steps at stations; 36 injured by being struck by barrows, falling over packages, etc., on station platforms; 48 injured by falling off platforms; and 2 killed and 71 injured from other causes. Of servants of companies or contractors, 3 killed and 979 injured while loading, unloading, or sheeting wagons; 2 killed and 292 injured while moving or carrying goods in warehouses, etc.; 3 killed and 162 injured while working at cranes or capstans; 2 killed and 363 injured by the falling of wagon-doors, lamps, bales of goods, etc.; 3 killed and 404 injured by falling off, or when getting on or off, stationary engines or vehicles; 7 killed and 292 injured by falling off platforms, ladders, scaffolds, etc.; 2 killed and 225 injured by stumbling while walking on the line or platforms; 190 injured while attending to stationary engines in sheds; 1 killed and 50 injured by being trampled on or kicked by horses; 8 killed and 490 injured while working on the line or the sidings; and 3 killed and 256 injured from various other causes. Of other persons, most of whom were transacting business on the companies' premises, 19 were killed and 160 injured, making a total in this class of accidents of 58 persons killed and 4,157 injured.

Thus the total number of personal accidents reported to the Board of Trade by the several railway companies during the year amounts to 977 persons killed and 7,747 injured.

The Distribution of Hydraulic Power in London.

(Abstract of paper read before the British Institution of Civil Engineers by E. B. Ellington.)

THE Author observed that water power is no new force, but that, as formerly understood, it was limited in its application to systems of mechanism suitable for the low pressures found in nature. The effects obtained by the use of high pressure were so different in degree from all previous experience that a new name was needed, and had been found in the term "hydraulic power." Bramah's genius produced the hydraulic press, and he clearly foresaw the future development and great capabilities of his system; but it was reserved for Lord Armstrong to work out and superintend the intricate details that had to be developed before the system could be made fully serviceable. The public supply of hydraulic power in London constitutes the latest development of this system. The hydraulic power is supplied through mains charged by pumping at a pressure of 700 lbs. per square inch. The first and largest pumping station has been erected on a site known as Falcon Wharf, about 600 ft. east of Blackfriars Bridge. The engine-house at present contains four

sets of pumping-engines, each set being capable of exerting 200 indicated H.P. The engines are vertical-compound, of a type comprising the advantages of a three-throw pump with direct connection between the pump-plungers and the steam-pistons. Each set of engines will deliver 240 gallons of water per minute into the accumulators, at 750 lbs. pressure per square inch, at a piston speed of 200 ft. per minute. This is the normal speed of working, but, when required, they can be worked at 250 ft. per minute, the maximum delivery being 300 gallons per minute. The condensing water is obtained from storage tanks over the engine-house, and is returned by circulating pumps to one or other of those tanks. The water delivered into the mains is maintained all the year round at temperatures of between 60° and 85° Fahr. The boilers are of the double-flued Lancashire type, and are made of steel. All are fitted with Vicars's mechanical stokers. At the back of the boilers is a Green economizer, consisting of 96 tubes. The economizer and the stoker gear and worm are driven by a Brotherhood three-cylinder hydraulic engine.

The reservoir of power consists of accumulators. The accumulators at the pumping station are two in number, each having a ram 20 in. in diameter and of 23-ft. stroke. The weight cases are of wrought iron, and are filled with iron slag. The total weight of the case and load on each ram is approximately 106 tons, corresponding to a pressure of 750 lbs. per square inch. The storage tanks form the roofs for the engine and boiler houses. The water for the power-supply is obtained from the River Thames, and is pumped into the tank over the engines. The water passes through the filtering apparatus by gravity into the filtered-water tank over the boiler-house, which is 7 ft. below the level of the unfiltered-water tank. The filters consist of cast-iron cylinders, and each contains a movable perforated piston and a perforated diaphragm, between which is introduced a quantity of broken sponge ; the sponge is compressed by means of hydraulic pressure from the mains. The delivery of power-water from the Falcon Wharf pumping station is through four 6-in. mains. The most distant point of the mains from the accumulators is at the west end of Victoria Street, and is 5,320 yards, or just over 3 miles. To provide for all frictional loss in the pipes and valves, the accumulators have been loaded to 750 lbs., the stated pressure supplied being 700 lbs. per square inch. The total length of the mains at present laid is nearly 27 miles. The mains are laid in circuit, and there are stop valves at about every 400 yards, so that any such section of main can be isolated. The method employed for detecting leakage is based upon an automatic record of the number of gallons delivered into the mains, and in cases of abnormal increase during the night, if found to arise during the early hours of the morning, the mains are tested. The power-water used is invariably registered through meters on the exhaust pipes from the machines, and from the meters passed to the drains. There is a sliding scale of charges from 8*s*. ($2) to 2*s*. ($0.50) per 1,000 gallons at 700 lbs. pressure per square inch, designed to meet, as nearly as possible, the variable conditions and requirements of consumers. The more continuous the use, the lower the charges. The scale is intended chiefly for intermittently acting machinery, and experience has fully proved that these rates are sufficiently low to effect a large saving to the consumer in almost all cases, whether for a large or a small plant. The Author believes any idea of supplying power from a central source, at rates much below these, to be chimerical. The practical efficiency of the hydraulic system may be fixed at from 50 to 60 per cent. of the power developed at the central station. No other method of transmission would, to say the least, show a better result ; and the general convenience and simplicity of the hydraulic system are such that its use would hardly be affected even if there were no direct economy in the cost of working.

In addition to the general supply of hydraulic power, in the city and adjoining districts, to the 650 machines at present worked, a new departure has been taken by the application of hydraulic power to an estate at Kensington Court, the name given to an area of about 7 acres, facing Kensington Gardens. Seventy houses and dwellings are to be built on this estate, of which 30 have been already erected. Each house is fitted with a hydraulic lift, taking the place of a back staircase, and the power-supply is provided on the estate expressly for working these lifts. The driven machinery is as of great importance to an economical and satisfactory result as the distributing plant, but this obvious fact is not always understood. General regulations have been prepared by the Author, defining the conditions to be observed by manufacturers in fitting up machinery for connection to the power mains. They are intended to secure safety and an efficient registration of the quantity of power used ; but they leave the question of the economy and of the efficiency of the machines to be settled between the consumers and the makers. In London more lifts are working from the mains, and more power is used by them, than by any other description of machinery. The number of all classes at present at work is over 400. The principal types in use were fully described. In some cases there have been, by adopting the public supply, a saving in the cost of working of about 30 per cent., as compared with the steam-pumping plant previously in use. Lifts are now becoming so general, and the number of persons who use them is so great, that the author considered it necessary to urge the importance of securing the greatest possible safety in their construction by the general adoption of the simple ram. Suspended lifts depend on the sound condition of the ropes or chains from which the cages hung. As they become worn and unreliable after a short period, it is usual to add safety appliances to stop the fall of the cage in case of breakage of the suspending ropes, but they cannot be expected to act under all circumstances. As an indication of the important part which lifts occupy in a modern hotel, it may be mentioned that at the Hôtel Métropole there are, including the two passenger lifts and that for passengers' luggage, no less than 17 hydraulic lifts in use day and night, while the work done represents about 2,000 tons lifted 40 ft. in this time. The next largest use of the power is for working hydraulic cranes and hoists of various kinds along the river side and in the city warehouses.

It often happens that the pressure in the power mains is not sufficient for pressing purposes. The apparatus known as an intensifier is then used, by which any pressure required can be obtained. Hydraulic power is also used at Westminster Chambers, and elsewhere, for the purpose of pumping water from the chalk for domestic use. The pump is set going in the evening, and continued working till the tanks are full, or until it is stopped in the morning. For work of this kind, done exclusively at night, a discount is allowed from the usual rates. Mr. Greathead's injector hydrant, made at the Elswick Works, has been in use to a limited extent in London in connection with the power mains. A small jet of high-pressure water, injected into a larger jet from the water works mains, intensifies the pressure of the latter in the delivery hose, and also increases the quantity. By this means a jet of great power can be obtained at the top of the highest building without the intervention of fire-engines. This apparatus enables the hydraulic power-supply to act as a continuous fire-engine wherever the mains are laid, and is capable of rendering the greatest assistance in the extinction of fire ; but there is an apathy on the subject of its use difficult to understand. In Hull, the corporation has had put down a number of these hydrants in High Street, where the hydraulic power mains are laid, and they have been used with great success at a fire in that street. The number of machines under contract to be supplied with power is sufficient, with a suitable reserve, to absorb the full capacity of the station at Falcon Wharf, and another station of about equal capacity is now in course of erection at Millbank Street, Westminster. The works have been carried out jointly by the Author and Mr. Corbet Woodall, Mr. G. Cochrane being Resident Engineer and Superintendent. The pumping-engines, accumulators, valves, etc., and a considerable portion of the consumers' machinery, have been constructed at the Hydraulic Engineering Works, Chester. Sir James Allport, who was the first to adopt hydraulic power for railroad work, has been associated with the enterprise from the commencement of its operations in 1882. His wide influence and extended experience have greatly assisted the commercial development of the undertaking.

Quadruple-Expansion Yacht Engines.

(From the London *Engineer*.)

THE accompanying illustrations show a new type of quadruple-expansion engine lately built by Fleming & Ferguson, of Paisley, Scotland. The illustrations are taken from the drawings of small engines of about 120 H.P., which are to be placed in a yacht being built for Mr. Sholto Douglas. We may mention, however, that Messrs. Fleming & Ferguson have now in hand engines of a similar type, which are to indicate 1,800 H.P.

Referring to our illustrations, fig. 1 is an end elevation, fig. 2 a front elevation, and fig. 3 a plan. It will be seen that the arrangement is peculiar, all the cylinders being placed on one level. The advantage in getting a lower engine will be at once apparent, and this at least should be a very desirable feature in applying these engines to war-ships. As neither of the two piston-rods of each pair of cylinders can be over the crank-shaft, the axis of which is in the usual place in the middle of the engine-bed, the ordinary connecting-rod is replaced by a steel casting, as shown in fig. 1. Attached to the crosshead of each piston-rod is a link, the lower end of these links being attached to the triangular steel casting which takes the place of the connecting-rod. The lower end of the casting has brasses in which the crank-pin works in the usual way. There is a lever, or rock arm, which pivots on a pin in the engine framing, the other end being attached to a pin on the connecting piece as shown in fig. 1. In the engine in question a prolongation of this arm is used to work the air pump, etc. The two pistons of each pair of cylinders ascend and descend not quite together, one being a little in advance of the other. Consequently there is no dead center for either crank.

Fig. 1.

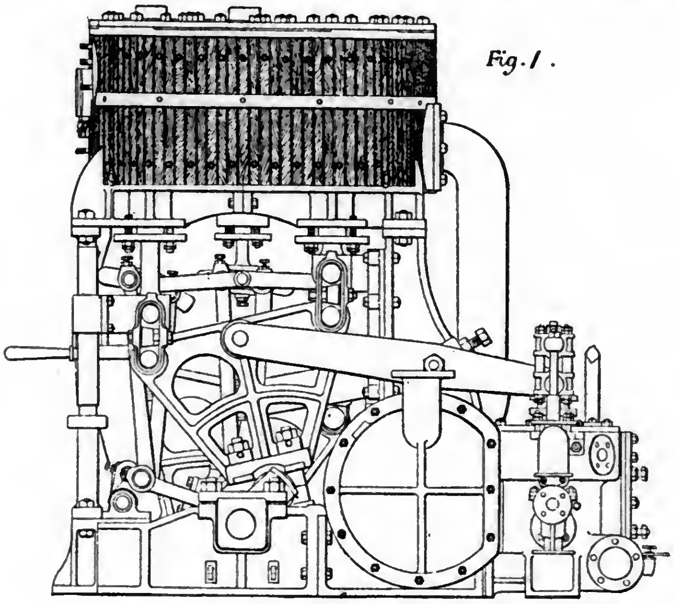
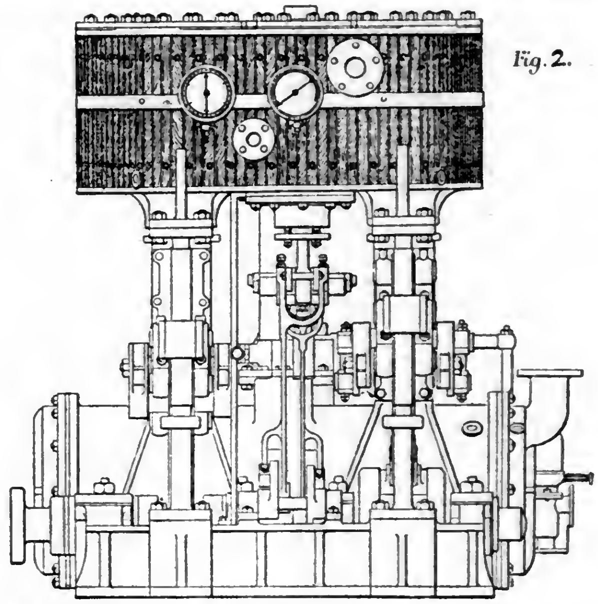
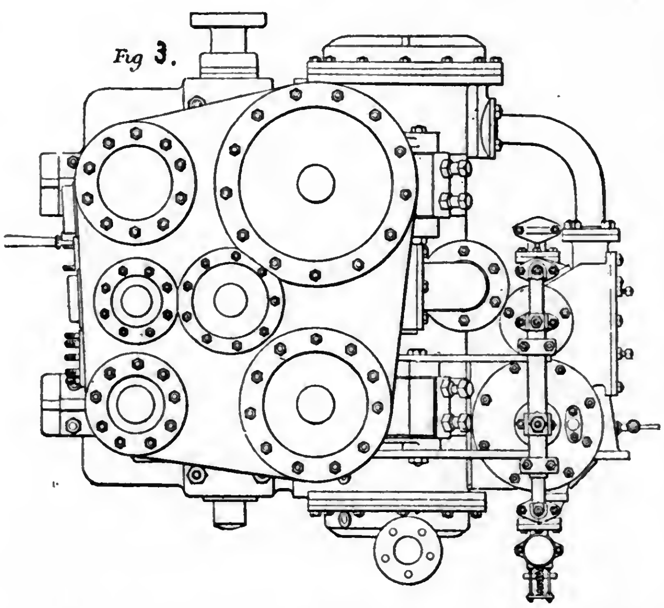


Fig. 2.



QUADRUPLE-EXPANSION ENGINE FOR SMALL STEAMER.

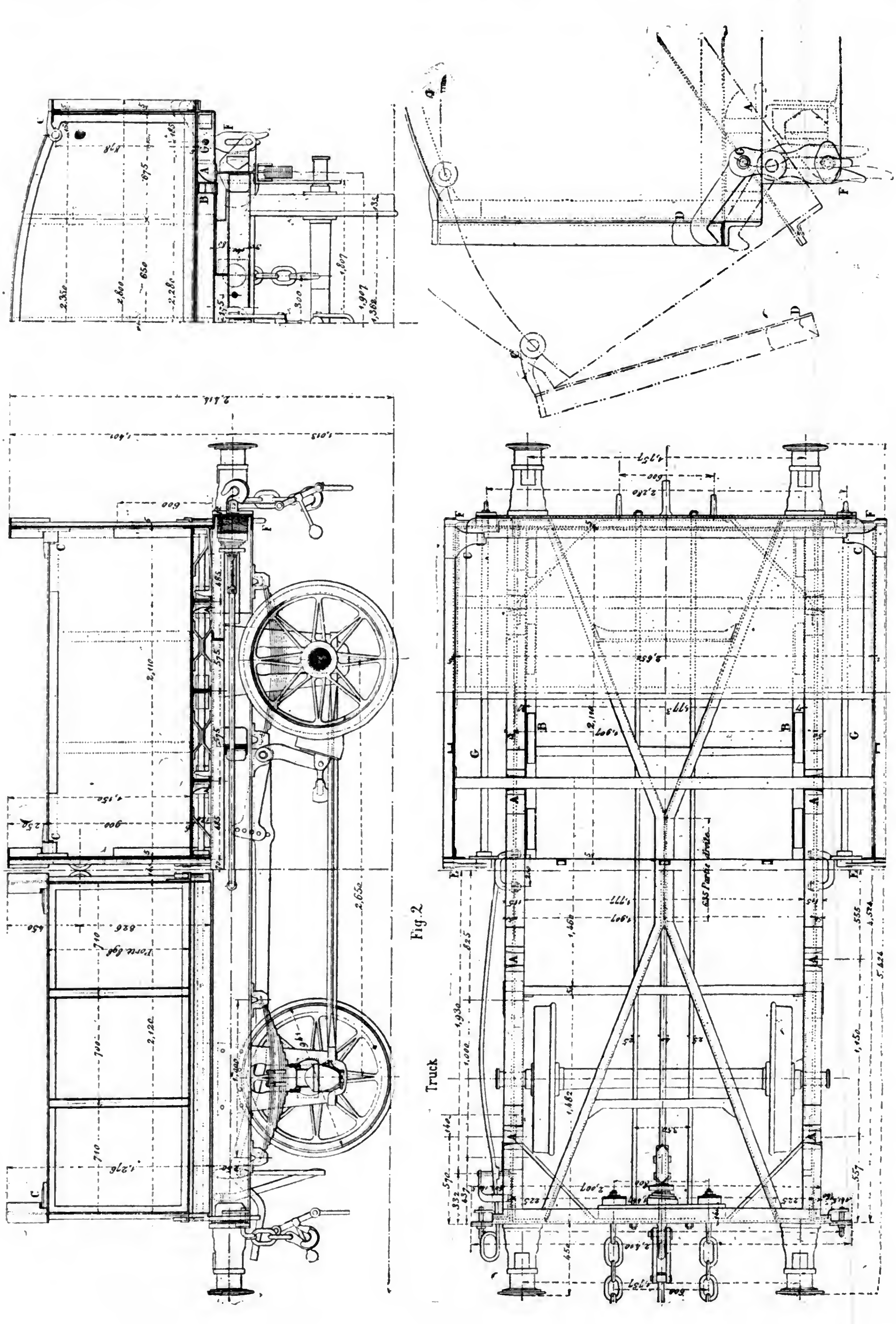
Fig 3.



The sequence of the cylinders will be seen from the plan, fig. 3. Steam is admitted to the high-pressure cylinder by means of the piston-valve placed between the first two cylinders. The steam passes first into the space between the flanges of the valve, and not into the steam-chest. From thence it is admitted to the cylinder through the center cylinder port, and, having done its work, exhausts into the casing. It must be now explained that the valves to each pair of cylinders are placed one above the other on one valve-rod, and work in one steam-chest common to both. It will be seen, therefore, why it is necessary for the boiler steam to be admitted inside the valve, or, in other words, between the flanges, as otherwise the high-pressure steam would pass into the second cylinder as well as the first, the valve-chest space being common to both valves and cylinders. The steam escaping from the first cylinder fills the valve-chest, and is admitted to the second cylinder in the usual way, the exhaust this time being carried by the inside of the valve. Steam is then taken to the two next cylinders, and the same action is gone through once more, until the steam escapes to the condenser in the usual way.

The valves are worked by eccentrics and reversed by link motion, but the arrangement is necessarily peculiar. The valves for the third and fourth cylinders are placed directly over the crank-shaft, and can be worked from eccentrics in the usual way. The valves for the first and second cylinders, however, are considerably on one side of the fore-and-aft center line. In order to work the valve-rod common to these, an arm or connecting-rod is taken from each of the eccentric straps, and these arms work the link motion by means of a bell-crank lever attached to the engine-bed. In fig. 1 the arm of one eccentric can be plainly seen together with the bell-crank lever, and the connecting-rod carrying the motion, to the solid bar link. The reversing links are placed one immediately in front of the other, and are pulled over by one lever and drag links. It will, therefore, be seen that only two eccentrics are used for all four cylinders, and only one would be required in a non-reversing engine.

The standards of the engine are used as crosshead guides, and the rubbing surface is less than usual, but with the arrangement of connection between crosshead and crank-pin here shown, the side thrust is very small, and there is little wear on the slipper guides.



IRON DUMP CAR, NORTHERN RAILROAD OF FRANCE.

The advantages the makers claim for this design of engine are, that free access is offered to each cylinder, less fore-and-aft space is taken up, and also less height. There are fewer wearing parts and less attention in running is required, consequently a cheaper upkeep is obtained. The two cranks being placed directly opposite each other give a balance of moving parts. It is also claimed that the turning action of the four pistons on the crank-shaft is equal to four cranks at right angles.

These engines are, we are informed, designed to work at a pressure of 180 lbs. to the square inch, and have been run light at 400 revolutions per minute. We had an opportunity of seeing these engines at work at Messrs. Fleming & Ferguson's works a few days ago, and they certainly ran very smoothly and pleasantly. The test was not a fair one, however, as the boiler pressure was only 60 lbs., and the last cylinders could have been getting very little steam. The diameters of cylinders are, first cylinder, 7 in.; second cylinder, 9 in.; third cylinder, 12½ in.; and fourth cylinder, 18 in. The stroke is 12 in. in all of them.

A French Iron Coal Car.

(From the *Portefeuille Economique des Machines.*)

FOR a long time there have been used for carrying coal, cars of considerable capacity having bodies which tip in order to facilitate the unloading and in certain cases the loading. The body is raised up at one side either by a lever or by a hydraulic cylinder, and the opposite side can be opened in order to allow the contents of the car to escape. The different classes of cars designed for this purpose resemble each other to a considerable extent, the chief difference usually being in the method of opening the sides of the car. A car of this kind, which is of very excellent design, and of which a large number are used for the transportation of coal on the Northern Railroad of France, has been designed by M. Malissard-Taza; these cars are built in the Taza-Villain shops at Anzin.

The accompanying illustration shows one of these cars, fig. 1 giving a half elevation and longitudinal section; fig. 2 a half plan of the body and a half plan of the running gear; fig. 3 a cross-section, and fig. 4 an end view, the dotted lines showing the position of car while dumping.

The frame of the car and the running gear are very much like those of other coal cars; they carry two boxes or bodies which can be tipped so as to dump on either side. These bodies, made of wrought iron, are supported on the frame of the car at each end and by two cross-sills made of double channel iron. On the side of the car frame under each of the dumping boxes are fixed four iron lugs *A*, the inside of which have the form of a quarter circle. These are placed two on each side, as shown in the engraving.

The sides of the box or dumping body are fastened to the upper edge by eccentric hinges *C*; on the lower corner of each of these boxes is fixed a triangular piece *D*. The latches or dogs *E* and *F*, keyed upon a shaft *G*, catch when in position on these triangular pieces *D*, and hold the sides of the car shut. The latch *F* has a vertical arm in the form of a fork, which hangs down between two iron plates fixed, one lengthwise, the other crosswise, on the frame. These two plates are pierced with a slot to receive a pin which prevents the forked arm of the latch *F* from leaving its position, and consequently prevents the latch from letting go.

To open one side of the box the pin is lifted and the longer branch of the fork *F* is turned back, this causing the shaft *G* to turn and lift the latches from the triangular pieces *D*. If the opposite side of the box is then raised the door opens on its hinges *C* and allows the contents of the box to pass out. The action is very clearly shown by the dotted lines in fig. 4.

When the box is empty it is lowered back into a horizontal position; the side or door then falls shut, and the latches fall into their places; the pin is then replaced in the fork *F*. This pin, upon which dependence is placed to hold the sides of the wagon, is so arranged that in case it should not be properly locked it will still keep it in place by gravity, and it is not likely to be shaken out by the motion of the car.

The car which we have just described is made entirely of iron, weighs 13,200 lbs., and carries 22,000 lbs. of coal. It has been adopted by the Northern Railroad Company, and a large number of the same pattern are also owned by mining companies which ship their products over that road.

Legislative Prevention.

WE reproduce below the last editorial written before his death by Mr. James Gillet, late editor of the *National Car and Locomotive Builder*. It has a direct bearing on one prominent subject of discussion at the Master Car-Builders' Convention this year.

There are a great many crying evils in railroad operation which imperil the safety of every person who travels on passenger or freight trains, or who crosses or walks upon a track, or is employed in track-yards; and these evils are of such a nature as would seem to justify prompt legislation to prevent, at least to some extent, the casualties that are occurring every day all over the land. But in spite of the urgent and increasing need, this kind of legislation has been very tardy in the past, and in all probability will continue to be so in the future, not from any criminal indifference on the part of railroad companies, the general public or legislative bodies, but from the difficulty of bringing about concerted action based upon and sustained by a unanimous public sentiment. We have a great many boards of railroad commissioners whose duty it is to exercise a vigilant supervision over the roads, point out defects in their methods of operation, and aid the lawmakers in framing enactments for the protection of the community.

The subjects which involve more directly the security of persons in life and limb are freight-train brakes and couplers, grade crossings, the construction of bridges and trestles, and the heating of cars. Many more might be named, but these are the most prominent from the fact that they have been talked about until their discussion has almost become wearisome from repetition. Commissioner Coffin, of Iowa, whose efforts to mitigate the perils to which trainmen are exposed have been earnest and unremitting, says in a special report that there is no longer a particle of excuse for delay in compelling railroads to use power brakes and a self-coupler of the Janney type on freight trains. The report of the Massachusetts Commissioners reiterates what nobody denies, that grade crossings are dangerous on single tracks and more so on double tracks, and should be abolished along with the private crossings, which are also very numerous in the State. Bridges of bad design and faulty construction are referred to in terms of emphatic condemnation; but in regard to car heating, no definite recommendation is made, although considerable space is devoted to the subject. The brake and coupler questions, it may be said, are not just now in a shape for legal interference, and as respects car heating, the results of experiments during the past winter are awaited to enable legislators to act intelligently in dealing with the subject. . . . There is no danger of a popular uprising to wipe all the railroads out of existence in order to insure safety in traveling, and have an end of the sickening horrors that are now paraded every few days on newspaper bulletins. The members of legislative bodies of the average sort, when dealing with these subjects, are apt to be swayed by conflicting interests and opinions. The safety of trainmen and passengers is professedly the paramount object to be attained, but it is liable to be lost sight of or overslaughed by outside pressure, or the possible danger of legislating a fortune incidentally into the coffers of individuals or companies who happen to control the patents. Or, in case no patents are involved, the law-making Solons may become perplexed upon questions of expediency as to what is really the best thing to do, especially when such questions are raised by railroad companies themselves in regard to the proposed legislation.

CATECHISM OF THE LOCOMOTIVE.

(Revised and enlarged.)

BY M. N. FORNEY.

(Continued from page 277.)

CHAPTER XIII.—*(Continued.)*

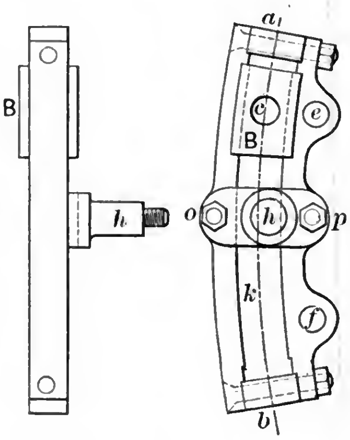
THE VALVE GEAR.

QUESTION 331. *How is the motion of either eccentric communicated to the valve?*

Answer. The ends of each pair of eccentric-rods are connected together by a link, *a b*, figs. 197 and 198. This link has a curved groove or slot, *k*, in it, in which a block, *B*, fits accurately, so that it can slide freely from one end to the other. This block is attached to the lower rocker-arm, *N*, by a pin, *c*, fig. 198, which works freely in the block. The two eccentric rods *C* and *D* are attached to the ends of the link at *e* and *f* by pins and knuckle-joints. It is apparent that if the link is down, or in the position shown in fig. 198 and also in the diagram, fig. 199, on a smaller scale, the motion of the upper eccentric-rod, which is usually used for the forward motion, will be imparted to the rocker, and thus to the valve, and when the link is in the position shown in fig. 200, that the valve will be moved by the lower or backward eccentric-rod *D*. In order to reverse the engine, it is then only necessary to provide the means of raising and lowering the link. This is done by a shaft, *A*, fig. 198, called a *lifting-shaft*, which has two horizontal arms, *E*,* one for each link, and a vertical arm, *F*. Each link is suspended from the end of one of the horizontal arms by a rod or bar, *g h*, called a *link-hanger*, which is connected to the link and to the arm above by pins, *h* and *g*, which enable the hanger to vibrate freely. The lower pin is attached to a plate, *o p*, called a *link-saddle*, which is bolted to the link. The vertical arm, *F*, of the lifting-shaft is connected by a rod, *G G*, called the *reverse-rod*, to a lever 20 21, IV and V, in the cab called a *reverse-lever*, the construction of which will be explained hereafter. This lever is worked by the locomotive runner, and by moving the upper end of it forward, the link will be lowered into the position shown in fig. 198, and also in the diagram, fig. 199, and the rocker and valve will then be moved by the forward eccentric; and if the reverse-lever is moved back, the link will be raised into the position shown in fig. 200, and the backward eccentric will then move the valve. When this is done, the valve-gear is said to be thrown into the *forward* or *backward motion*, or *forward* or *back gear*.

QUESTION 332. *How is the steam made to work more or less expansively?*

Fig. 197.

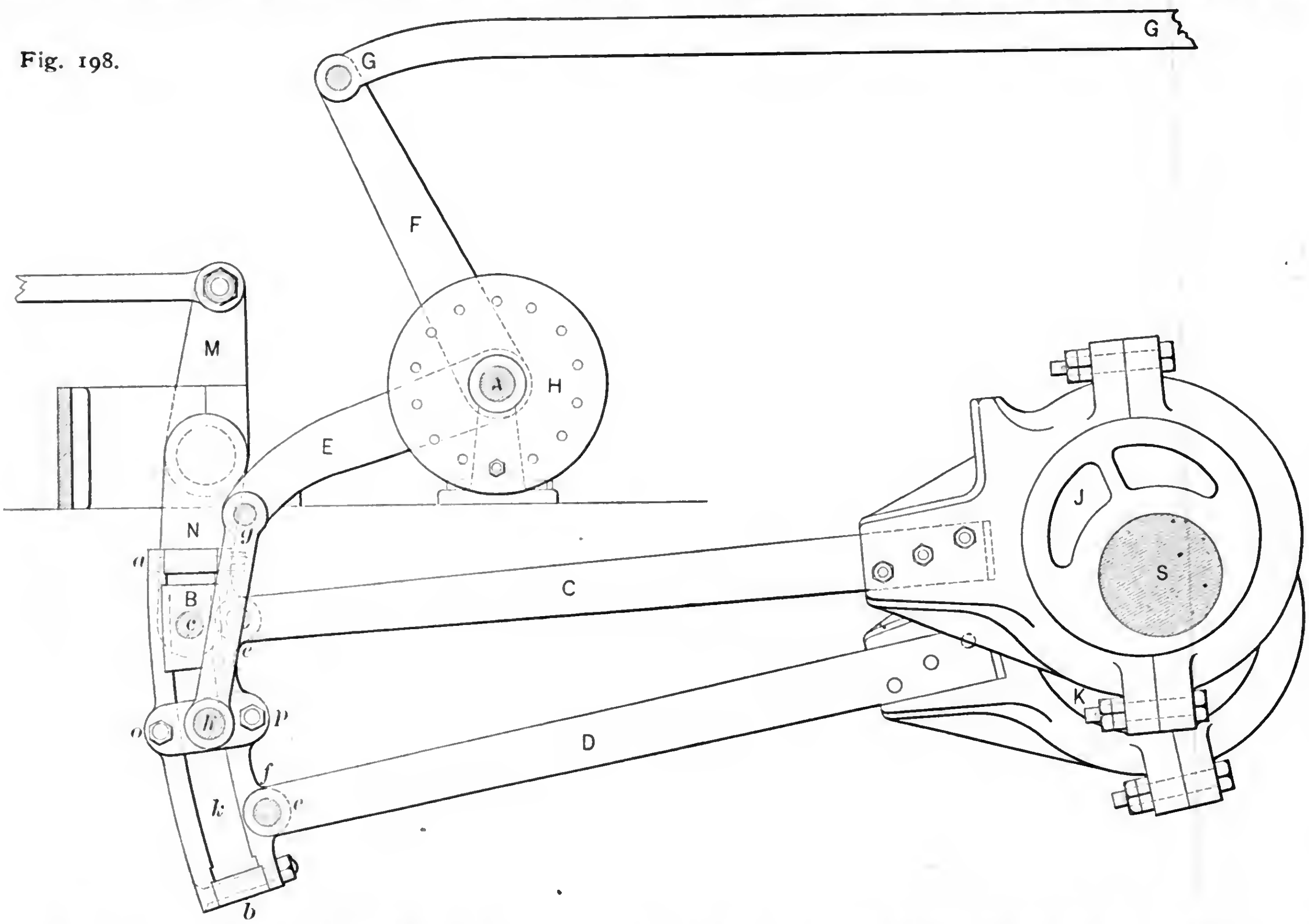


Answer. By changing the travel of the valve.

QUESTION 333. *How is the travel of the valve changed?*

Answer. By either raising or lowering the link, so that the link-block and rocker-pin will be some distance above or below the eccentric-rods. Thus in fig. 199, the motion of the upper eccentric-rod, and in fig. 200 that of the lower or *back* eccentric-rod is communicated to the rocker-pin and the valve. If, however, the link should be raised so that the link-block and rocker-pin are somewhat below the upper or forward eccentric-rod, as shown in fig. 201, then the motion imparted to the rocker and valve will partake somewhat of that of the upper and also of the lower eccentric-rod. So long as the rocker-pin is above the center of the link, the motion of the valve will partake most of that of the upper or forward rod, and the engine will then run forward; but when the rocker-pin is below the center of the link

Fig. 198.



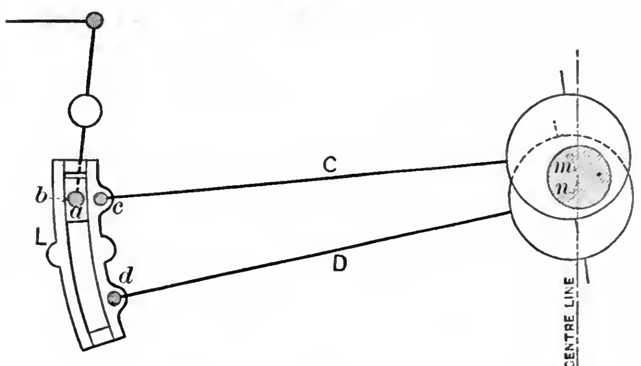
* Only one of these is shown in the engraving.

its motion will be influenced more by the back eccentric-rod, and the engine will then run backward.

The motion of the link, which is somewhat complex and difficult to understand clearly, will perhaps be understood better if we represent it in a number of successive positions of the whole stroke of the piston, as was done to show the motion of the eccentric in figs. 15 to 28. We will therefore suppose that the link is in what is called *full gear forward*, as shown in figs. 203 and 214. In fig. 203 the link is in the position it would occupy when the piston is at the beginning of its stroke; in fig. 203 it is in that which it will be in when the piston has moved four inches; in fig. 205, when it has moved eight inches; in fig. 206, twelve; and in figs. 207, 208, and 209, sixteen, twenty, and twenty-four inches. Figs. 209 to 214 represent the successive positions of the link during the return stroke.

In these figures the center-line of the slot in the link is represented by dotted lines, which are indicated by numbers preceded by a — or + sign. The numbers represent the distance that the piston has moved from the beginning of the stroke, when the link is in the position shown and the — sign indicates the backward stroke of the piston, and the + sign its forward

Fig. 199.



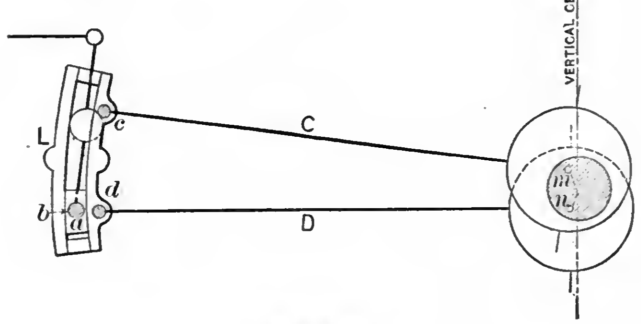


Fig. 200.

stroke. Thus in fig. 204 the figures — 4 — 4 indicate the dotted center-line, and also designate that the piston has moved 4 in. from the beginning of its backward stroke; when the link is in the position represented, and — 8 — 8, in fig. 110, that it has moved 8 in. of its backward stroke. To show the action of the link, the successive positions of the center-lines represented by figs. 108 to 119 have been laid down on a larger scale in the diagram, fig. 215. For greater clearness the center-lines are represented in full instead of by dotted lines, and are indicated by the same signs and numbers in the diagrams, fig. 215, that were used in figs. 203 to 214.

O, fig. 215, represents the rocker-shaft, and the dotted circles *a* and *b* two positions of the lower rocker-pin. As the center of the rocker-pin must always coincide with the center-line of the link, it is evident that the action of the link, as shown by figs. 203 to 214, will move the rocker-pin from *a* to *b*, fig. 215, a total distance equal to 5½ in.

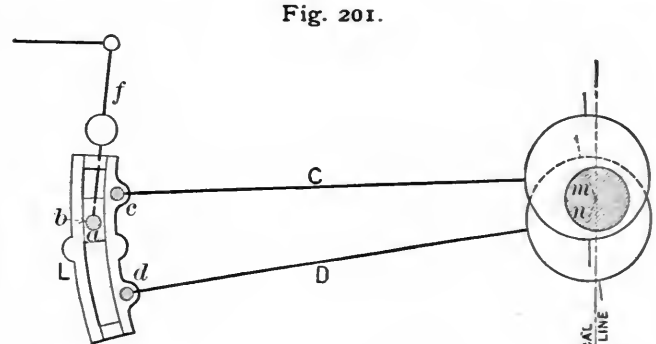
If, however, the link was raised up into the position shown in fig. 201, so that the rocker-pin is half-way between the end of the eccentric-rod and the center of the link, then the action of the link in relation to the rocker would be as represented in fig. 216, in which the different positions of the center-line of the link and of the rocker have been laid out with the link raised up for *half-gear*, as it is called, in the same way as was done for full-gear before. From this it will be seen that the travel, *a b*, imparted to the rocker-pin and valve by the link when it is in the position shown, instead of being 5½ in. is now only 3¼ in. In fig. 202 the link is represented in the position it would be in when it is raised up, so that the rocker-pin would be in the center of it or midway between the eccentric-rods. This position is called *mid-gear*. The successive positions of the center-line of the link in this position have been laid down in fig. 217 in the same way as was done for full and half-gear. The movement of the rocker, it will be seen, is, for mid-gear, only 2¼ in.

These diagrams show that when the rocker-pin is opposite the eccentric-rod, the valve receives the full or more than the full throw of the eccentric,* and that the motion imparted by the eccentric diminishes as the rocker-pin approaches the center of the link, so that, with eccentrics having 5 in. throw and a valve with ⅞ lap and ⅛ in. lead, we can increase or diminish the travel of the valve from 2¼ to 5½ in. by simply raising or lowering the link, which is done by the reverse-lever.

QUESTION 334. *What is the effect of this variation of travel on the working of the valve and the admission and release of steam to and from the cylinder?*

Answer. It is almost precisely the same as that which is effected by increasing or diminishing the throw of the eccentric, which was explained in the answer to question 121. In order to show this effect more clearly, we have represented by motion-curves, fig. 218, the movement imparted to the valve by the link when it is in full, half, and mid-gear, as illustrated in the preceding figures. The curve for full-gear is engraved in

Fig. 201.



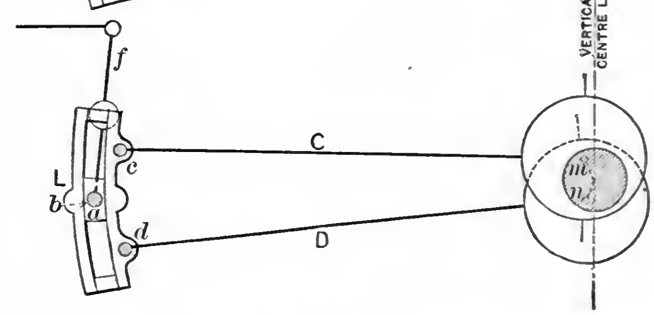


Fig. 202.

full heavy lines; that for half-gear, in lighter lines, and for mid-gear, in dotted lines.

QUESTION 335. *What may be learned from these motion-curves?*

Answer. They show the exact motion of the valve in relation to the steam and exhaust-ports during a complete revolution of the crank. Thus, if we take the curve *M N O P Q R S*, drawn in heavy lines, and which represents the movement of the outer edge of the valve in full-gear in relation to the port *c*, it will show first the lead of the valve at *M*. Then the intersection of the curve with the inner edge of the port above the horizontal line 3 21′ shows that the port *c* is then wide open. The outer edge of the valve then moves beyond the inner edge of the port, until the curve gets below the line 16 8′. The horizontal lines 0 24′, 1 23′, 2 22′, etc., represent inches of the stroke, and the intermediate lines divide the inches into eighths, as has been explained. The position of the curve on those lines, therefore, indicates that of the valve when the piston is at a corresponding distance from the beginning of its stroke. The diagram shows then that at 2½ in. of the stroke the port *c* is wide open, and that the valve begins to close it at 16½ in. of the stroke. The intersection of the curve with the outer edge of the port *c* below the line 21′ 3′ shows that this port is then closed, or the steam is cut off by the valve when it is working in full-gear.

The curve *M′ N′ O′ P′ Q′ R′ S′* shows the movement of the exhaust edge of the valve. It will be seen that at the beginning of the stroke, as shown at *M′*, the port *e* is nearly wide open for the escape of the steam, which is in the back end of the cylinder. The intersection of the curve with the outer edge of

* When the block is opposite the eccentric-rod at the beginning of the piston stroke, the link moves it a distance somewhat greater than the throw of the eccentric, owing to the fact that when the link assumes the inclined position shown in figs. 206 and 207 the block slips upward in the link slot. This slip of the block is, however, dependent on the way in which the link is suspended.

the port a little below the line 20 4′ shows that the valve has then commenced to close the port *e*, and another intersection with the inner edge below the line 23 1′ indicates that it is entirely closed before the piston has reached the end of the cylinder. The steam which remains in it when the valve closes is then compressed by the piston as it advances to complete its stroke. For this reason the point where the valve closes the port to the exhaust is called the *point of compression*. If we follow up the reverse side of the curve it will be seen that it intersects the inner edge of the port *e* at *Z* or near the line 1 23′. that steam is then cut off at about 15⅝ in. of the stroke, and that at no time is the port wide open. The curve *M′ n′ o′ p′ q′ r′ S′* shows that the valve begins to close the exhaust-port *e* to the exhaust at about 12 in. of the stroke, and that compression begins at about 21½ in. The intersection of the opposite side of this curve with the inner edge of the port *e*, at *z*, shows that *pre-release* or exhaust begins while the piston must still move 3½ in. to complete its stroke.

The dotted lines *M S* and *M′ S′* show the motion of the valve in mid-gear, and the curve then becomes a straight line.

Fig. 214.

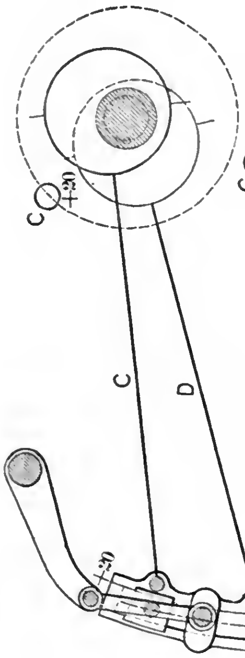


Fig. 213.

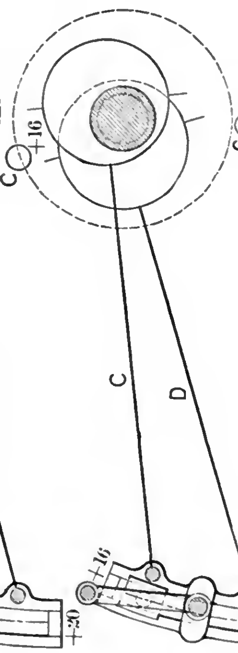


Fig. 212.

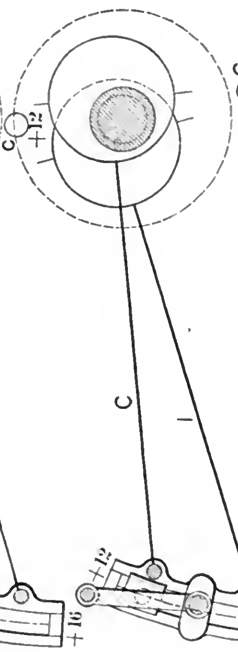


Fig. 211.

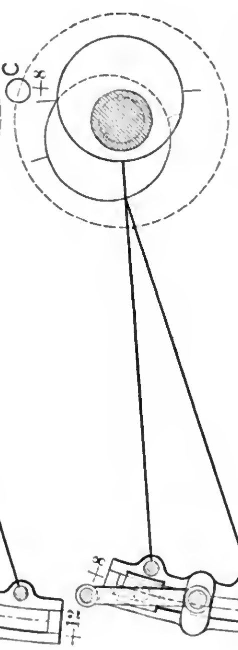


Fig. 210.

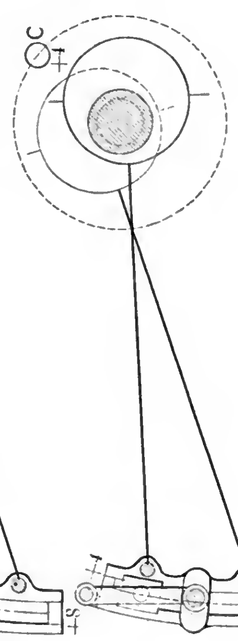


Fig. 209.

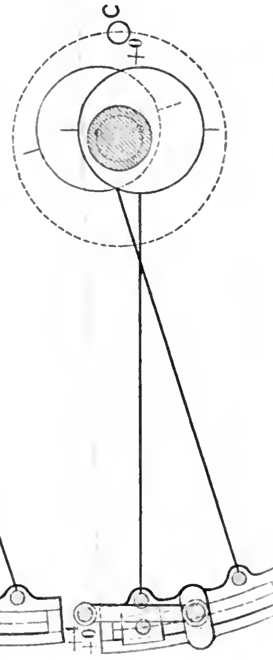


Fig. 203.

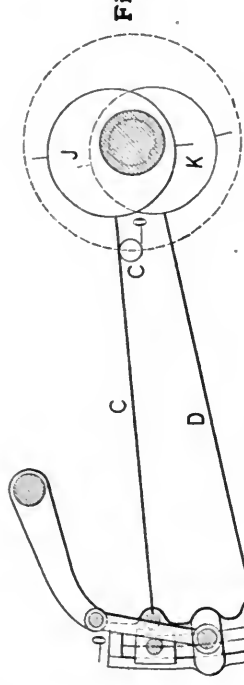


Fig. 204.

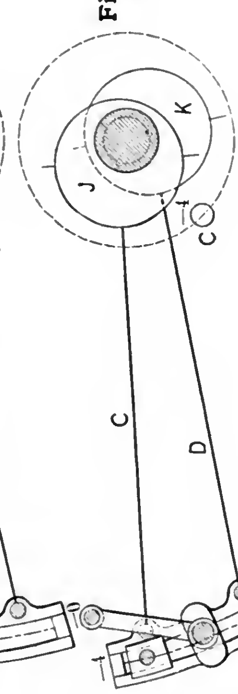


Fig. 205.

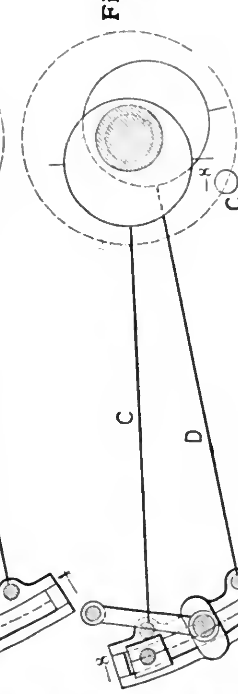


Fig. 206.

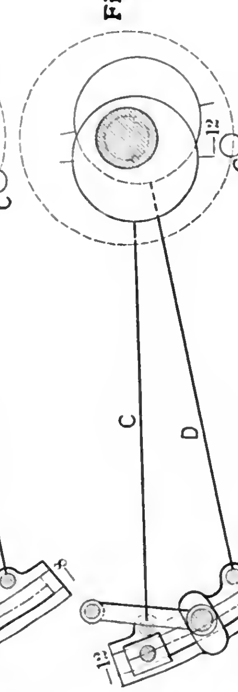


Fig. 207.

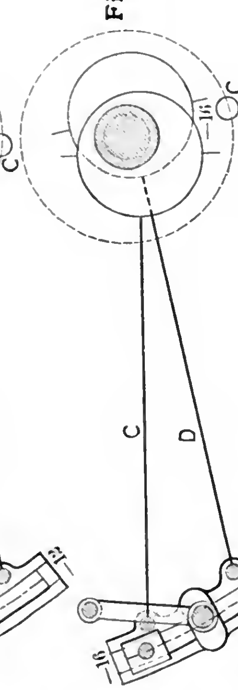
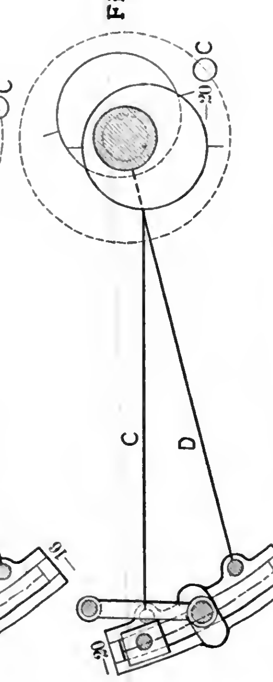


Fig. 208.



This shows that the port *e* is opened to the exhaust before the piston has completed its stroke. This is called the *point of pre-release*.

In the same way we may follow the curve *M n o p q r S*, which shows the movement of the valve in mid-gear. It shows that steam is then cut off at 3 in. of the stroke, and the exhaust-port is closed at 13½ in. The greatest opening of the steam-port, for the admission of steam, is then no greater than the lead.

It is of course possible to work the link in any intermediate position between those which we have represented.

QUESTION 336. *What is the greatest and the least admission of steam possible with the ordinary link motion?*

Answer. With 24 in. stroke of piston and 5½ in. travel and ⅞ in. lap, steam can be admitted as shown by the motion-curves during 21½ in. or nearly 90 per cent. of the stroke, and can be cut off at about 3 in. or 12½ per cent. It will be seen, however, that in mid-gear the *pre-admission* of steam—that is, the admission of steam before the piston reaches the end of the stroke, is equal to that admitted after, so that it is impossible to work the locomotive with the link in that position. Practically it is found that little useful work can be done with a link if the steam is cut off at less than six inches, or one-fourth of the stroke. Even then the opening of the steam-ports is so small that the steam which enters the cylinders is very much wire-drawn.

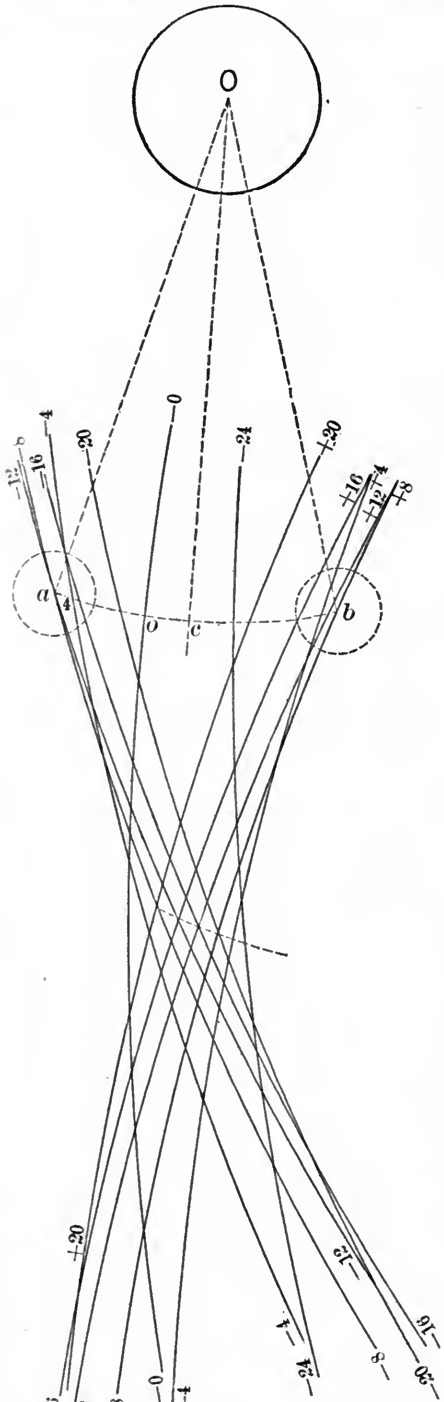


Fig. 215.

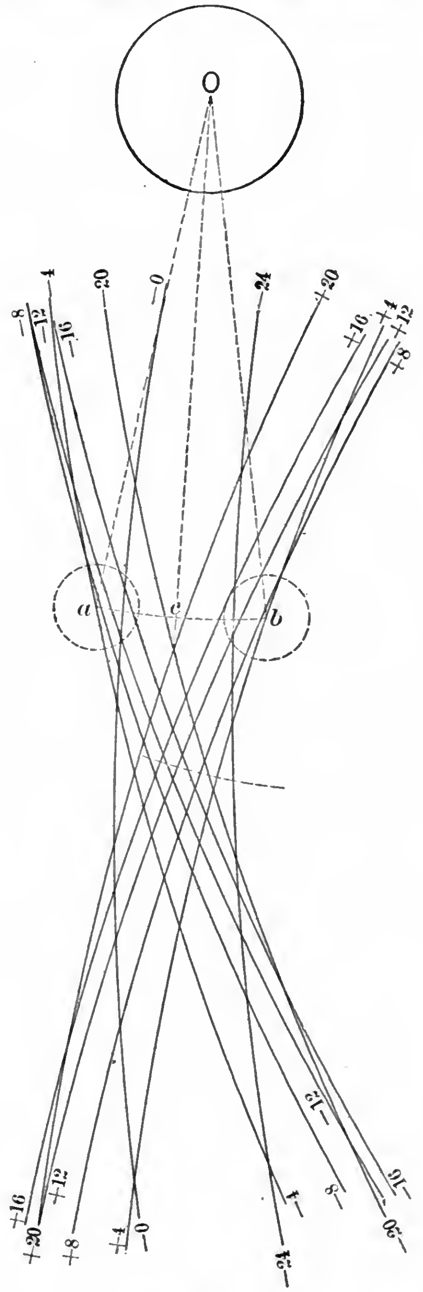


Fig. 216.

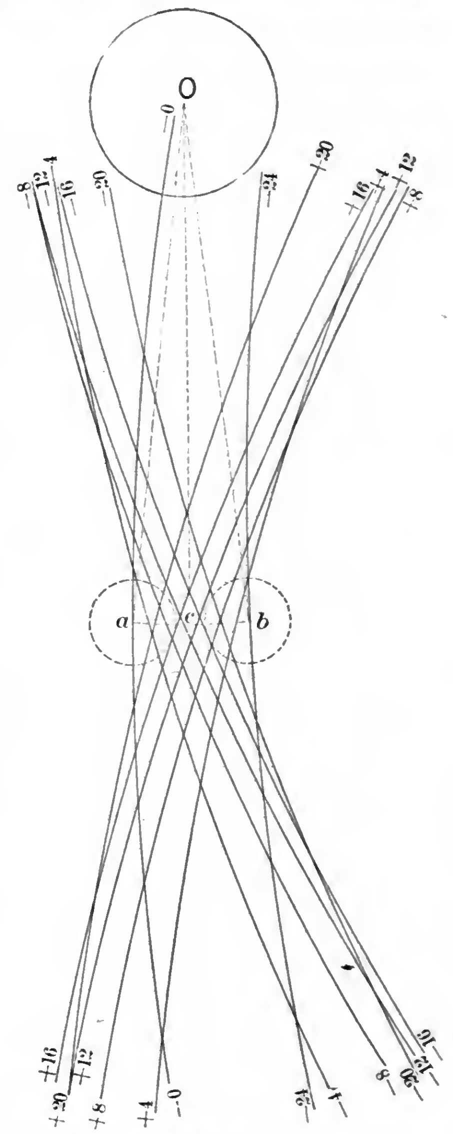


Fig. 217.

QUESTION 337. *How are the curves drawn which represent the motion of the valve?*

Answer. These motion-curves as produced by the link-motion are difficult to draw, as the motion of the link is very complicated. It is doubtful, therefore, whether those who have no knowledge of mechanical drawing will be able to understand the following description of the method of doing it.

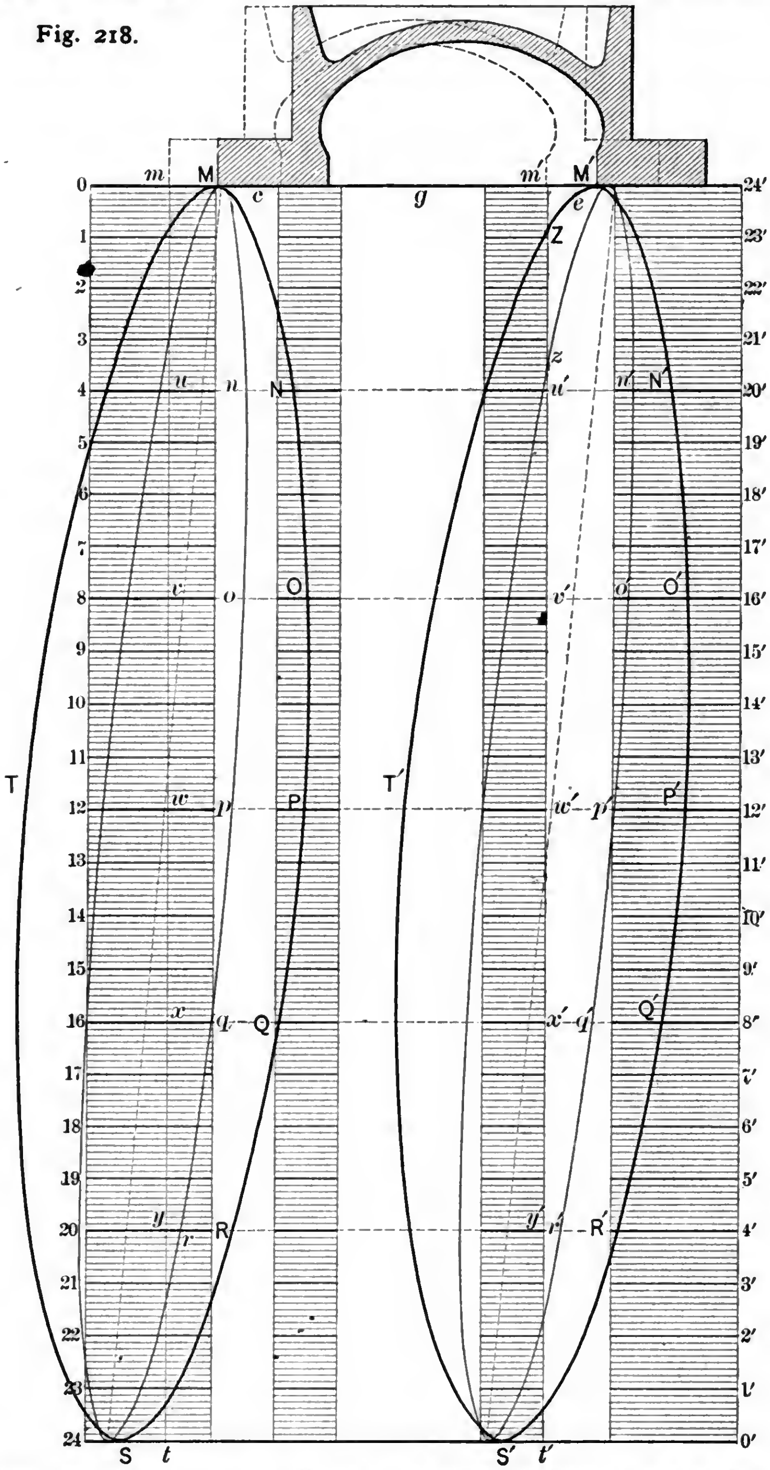
In the first place, the center *S*, fig. 219, of the axle, *O* of the rocker and *A* of the lifting-shaft must be laid down in their proper positions. If, now, the valve has ⅞ in. lap and $\frac{1}{16}$ lead, it must be $\frac{15}{16}$ in. from its middle position, and the lower rocker-pin, *c*, must be the same distance ahead when the piston is at the front end of the cylinder and at the beginning of the backward stroke. We will, therefore, mark the center, *c*, of the rocker-pin that far ahead of the vertical center-line *m n*, which represents the central position of the rocker.

If from the center of the axle a circle, *o p q*, be drawn, whose diameter is equal to the throw of the eccentrics, this circle will represent the path in which the centers of the eccentrics will revolve.

Another circle, *H I J N*, whose diameter is equal to the stroke of the piston, should be drawn from *S* as a center to represent the path of the center of the crank-pin. If the distance from the center *S* of the axle to the center of the lower rocker-pin, *c'*, when the latter is in its middle position, be taken for a radius, and from the position *c* of the rocker-pin, at the beginning of the stroke, as a center, the circle representing the path of the eccentrics be intersected at two points, *o* and *p*, the points of intersection will represent the positions of the centers of the forward and backward eccentrics at the beginning of the stroke of the piston. Having determined these positions, lay off a distance *c e*, from *c*, the center of the rocker-pin, equal to the distance *c e*, fig. 197, of the center-line of the link from the center of the pin *e*, by which the eccentric-rod is connected to the link. Then the distance *e o*, fig. 219, will be the length of the eccentric-rod. With the distance as a radius

and o and p as centers describe two arcs 1 2 and 1' 2'. Having laid down the position of the lifting-shaft A with A g, equal to the length of the lifting-arm E, describe an arc 3 4. As the link is suspended from g by the hanger g h, which oscillates from the end g of the lifting-arm in the arc 5 6, and as the lifting-arm, for any one point of cut-off, is stationary, therefore the point of suspension of the link must always be on the arc 5 6 described from the center of the pin g in the lifting-arm, with a radius equal to the length of the hanger. As the eccentric-rods are connected to the link by pins e and f, their centers must always coincide with the arcs 1 2 and 1' 2' described from the centers of the eccentrics by the length between the centers of the eccentric-rods as a radius.

Fig. 218.



To locate the position of the link, a drawing like fig. 197 should be made on a thin board or a stiff piece of paper. Then cut away the portion on the left of the center-line a b, as shown in fig. 221, so as to leave an exact outline of the center-line of the link. Draw lines through the centers e and f of the pins by which the rods are attached to the link, and cut off the portion on the right-hand side of these lines. As the center of suspension is usually back of the middle of the link, a notch should be made on the front side, as shown at h. Having cut the board or paper accurately to the form of the link, lay it on the drawing, fig. 219, so that the centers e and f will be on the arcs 1 2 and 1' 2', and the center of suspension, h, will be on the arc 5 6. When these three points coincide with the three arcs, the template will be in the position that the link would occupy when it is suspended from the point g, and the centers of the eccentric are in the position shown. When the position of the link is thus determined, draw a line on the edge a b to represent the center line of the link in that position.

Another position of the link may be laid out as follows: by the method described in answer to question 117, lay down the position N', fig. 220, of the crank-pin when the piston has moved any distance, say 4 in. of its stroke. Lay out the position of the centers o and p of the eccentrics the same as in fig. 219, and draw lines S o 7 and S p 8 from the center S of the axle through the centers o and p and intersecting the circle H I J N at 7 and 8.

Now, the crank-pin turns from N to N', while the piston is moving 4 in. from the front end of the cylinder. This is called its *angular motion*. As the crank and eccentrics are all fastened to the axle, they must all have an equal angular motion while the crank-pin is moving from N to N'. Therefore, if with a pair of dividers we take the distance N N' and lay it off from 7 to 9 and from 8 to 10, and draw lines from 9 and 10 to the center

of the axes, the intersection of these lines at o' and p' with the circle $o\ p\ q$ will represent the angular motion of the eccentrics, while the crank-pin is moving from N to N', and o' and p' will be the position of the centers of the eccentrics when the crank-pin is at N'. From these centers, with the length of the eccentric-rods as a radius, describe the arcs 1 2 and 1' 2', as before. Draw the arc 5 6 as in fig. 219, and then lay the template of the link on the drawing, and make its centers, h e and f, coincide with these arcs as before, and it will then represent the position of the link when the piston has moved 4 in., and the crank-pin is at N'. A line drawn along the edge $a\ b$ will represent this position of the center-line of the

intersection, o, of the line — o — o with the arc $a\ b$ represents the movement of the valve from its middle position, when the piston is at the beginning of its backward stroke. In fig. 218 the dotted lines $m\ m'$ represent the valve in the middle of the valve-face, the lines m and m' representing the outer or steam edge and the inner or exhaust edge of the valve. As the valve will be moved a distance equal to $o\ c$, fig 215, from its middle position when the piston begins its stroke,* and as this movement is reversed in direction by the rocker, if we lay off on the right side of m and m' distances $m\ M$ and $m'\ M'$ the points M and M' will represent the position of the edges of the valve at the beginning of the stroke. From m and m' vertical lines $m\ t$ and

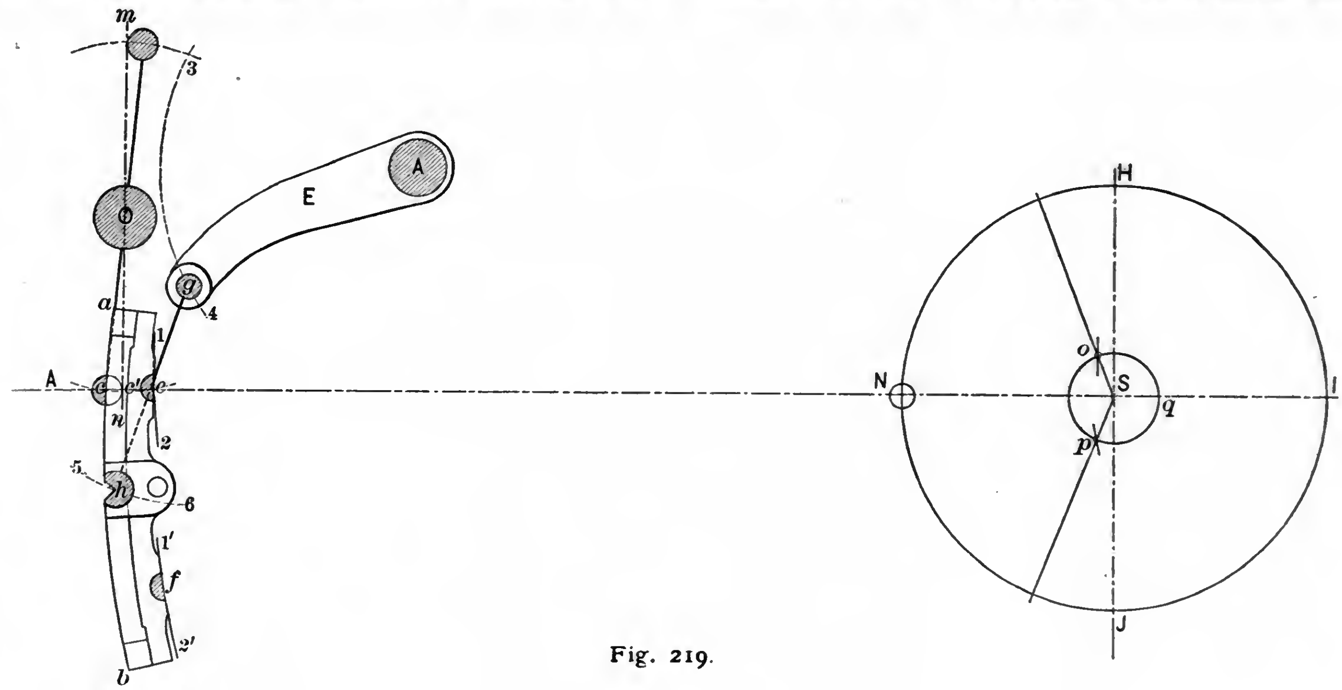


Fig. 219.

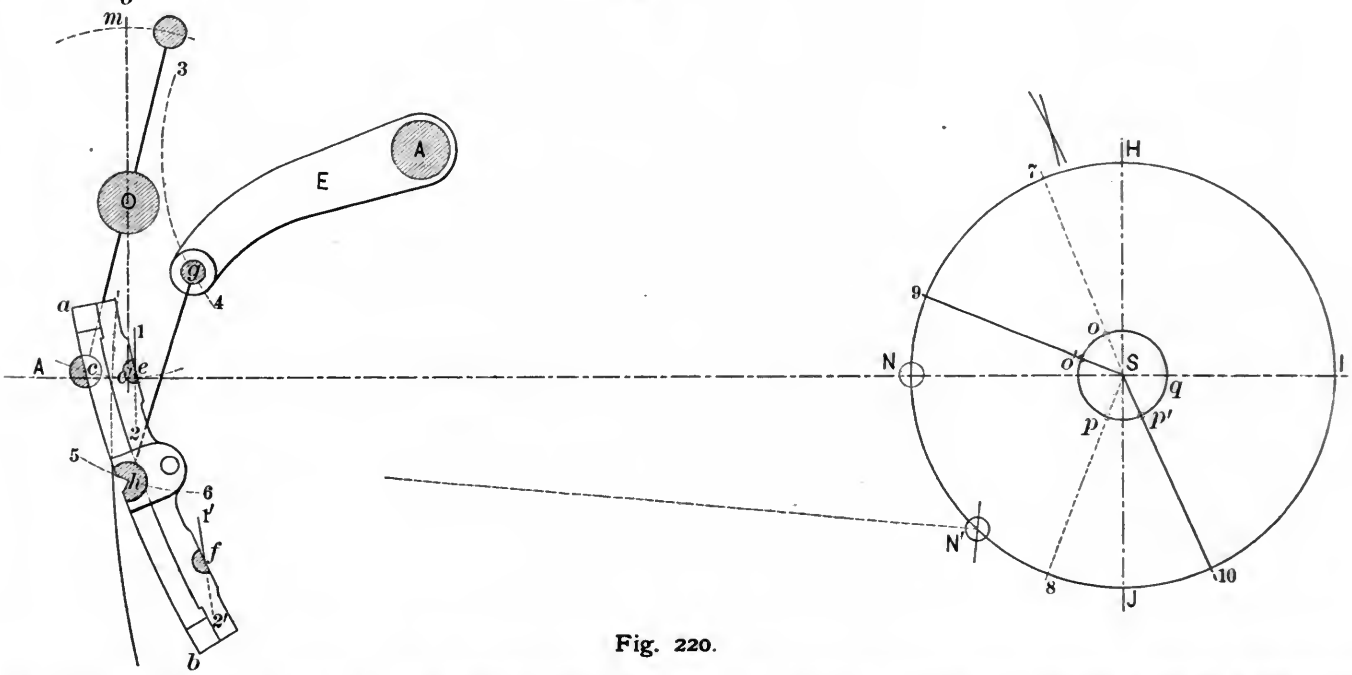


Fig. 220.

link. This process can be repeated for successive positions of the piston and crank-pin.

Such diagrams as have been described should be drawn to a larger scale than the engravings—preferably full size—and great care must be taken to lay them out with the greatest precision. A thin white pine board—about $\frac{3}{32}$ in. thick—is the best material to make the template of the link of. Great care must be taken to make the outline $a\ b$ so as to conform accurately to the center-line of the link.

QUESTION 338. *Having laid out the successive positions of the link, as shown in figs. 215-217, how are the motion-curves, fig. 218, drawn from them?*

Answer. In fig. 215 the arc $a\ b$ represents the path of the center of the rocker-pin, and the dotted line $O\ c$ the middle position of the lower rocker-arm. The distance of the point of

$m'\ t'$ are drawn to represent the position of the two edges of the valve when it is in the middle of the valve-face for all points of the stroke.

Proceeding as before in fig. 215, the distance of the point of intersection 4, of the line — 4 — 4, with the arc $a\ b$, 4 c, represents the movement of the valve from its middle position when the piston has moved 4 in. of its stroke. Taking this distance and laying it off from the vertical lines $m\ t$ and $m'\ t'$ on the horizontal line 4 20', fig. 218, we locate the points N and N' which represent the positions of the steam and exhaust edges of the valves when the piston has moved 4 in. In the same way the distance from c of the intersections of the lines — 8 — 8, — 12— 12, — 16 — 16, etc., in fig. 215, with the arc $a\ b$ can be

* This will be the case when the two arms of the rocker are of the same length, as they usually are. Sometimes they are of different lengths.

laid down on the horizontal lines 8 16', 12 12', 16 8', etc., in fig. 218, and the points *O P Q*, etc., and *O' P' Q'*, etc., are thus located. The curves *M N O P Q R S* and *M' N' O' P' Q' R' S'* can then be drawn through these points either by hand or by constructing templates, and the intersection of these curves with the intermediate horizontal lines in fig. 218 will represent the position of the steam and exhaust edges of the valve in relation to the ports *c g* and *e* for any part of the stroke of the piston. The more points there are determined, the more accurate will be the curves. It is, therefore, best to lay down the position of the valve for each inch of the stroke of the piston. The curves

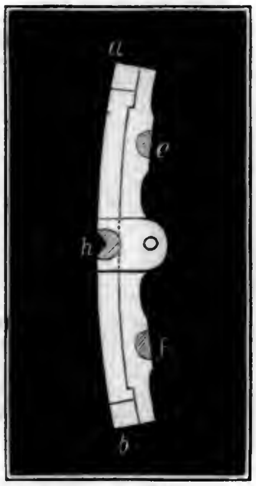


Fig. 221.

can be completed by drawing *S T M* and *S' T' M'* in the same way.

The curves *M n o p q r S* and *M' n' o' p' q' r' S'*, which show the motion of the valve when the link is in half-gear forward or in mid-gear, may be drawn in the same way from the diagrams, figs. 216 and 217, which represent the successive positions of the center-line of the link when it is in half and mid-gear forward.

In the illustrations the upper and lower rocker-arms are represented as of the same length, as already explained; in some cases they are of unequal lengths, which of course affects the motion of the valve. In the diagrams, figs. 219 and 220, the lower rocker-pin, *h*, is represented as being on the horizontal center-line *A N I* drawn through the center *S* of the axle. Usually the lower rocker-pin is located below this horizontal center line, so that the link will not strike the boiler when it is raised up into back-gear.

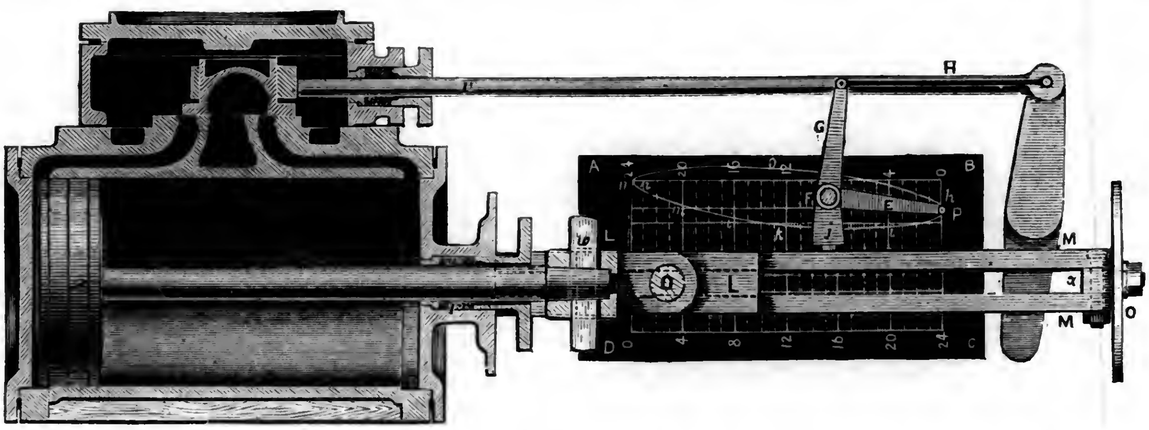
QUESTION 339. *Is there any other method of drawing these motion-curves?*

Answer. Yes; models which show the working of the valve-gear have been constructed, to which the reciprocating motion of the valve is imparted, and which traces a curve with a pencil on a surface having the same motion as the piston. This method has been employed by the writer in an instrument which he has applied to the locomotive itself. The principle upon which it works will be understood by supposing that the steam and exhaust-ports, as represented in the diagram for motion-curves, fig. 218, be drawn on a board, *A B C D*, fig. 222; but instead of standing vertical, as in fig. 218, they are represented in a horizontal position, and the board on which they are drawn is fastened to the cross-head *L*, so that the former will move backward and forward simultaneously with the latter and the piston. A small shaft, *F*, is attached to suitable supports, *J*, which are fastened to the guide-bars. This shaft has two arms, *G* and *E*, one vertical and the other horizontal and of the same length. The upper end of the vertical one, *G*, is then attached to the valve-stem or rocker-arm by a short connecting-rod, *H*, or other suitable means, so that the movement of the upper rocker-pin and the valve-stem will be imparted to the arm and shaft. The end *P*, of the horizontal arm *E* then has exactly the same motion vertically that the valve-stem and valve have horizontally, with the very trifling inaccuracy due to the fact that the movement of the one is in a straight line, whereas the other is in the arc of a circle.

Now if a pencil, *P*, is attached to the end of the horizontal arm *E*, and is set so that its point indicates the exact position of the steam edge, *M*, of the valve, as shown in fig. 218, it is obvious that when the piston and board have moved four inches, the pencil will have moved downward and have drawn the portion of the motion-curve from *h* to *i*; and when the piston has moved eight inches the curve will be drawn to *j*, and at 12, 16, 20, and 24 inches of the stroke the curve will be drawn to *k l m* and *n*. During the return stroke a corresponding curve, *n o h*, will be drawn. With such an instrument curves can be drawn for any position of the link, and they will show the exact movement of the valve during the whole stroke, and will indicate all the defects resulting from bad proportions or construction, lost motion in the parts, or other causes of error or irregularity.

In using this instrument, however, it is usually impracticable to attach a board to the inside of the cross-head, and it must therefore be fastened to the outside. The horizontal arm *E* should be made of thin steel, so as to form a spring. The end has a small *boss*,* *P*, with a hole in it $\frac{3}{16}$ in. in diameter. This hole has a screw-thread cut in it, into which an ordinary hard drawing-pencil is screwed. The spring is so arranged that the pencil will not be in contact with the board unless it be pressed against it. The locomotive is then placed on a smooth piece of track with steam on and run very slowly, so that a person walking alongside can press the pencil against the surface of the board, which should be covered with drawing-paper. By watching the cross-head when it reaches the end of the stroke, the pencil can then be pressed against the paper and kept in contact through the whole stroke and instantly released when the motion-curve is completed. The link can then be placed in another position, and thus any number of curves can be

Fig. 222.



drawn, which will furnish an accurate means of analyzing the motion of the valve.

In practice it is best not to draw the lines which represent the edges of the ports until after the curves are drawn and the paper removed from the board. A line must, however, be drawn on the engine from which to lay off the ports. This can be done by placing the valve in its middle position, and then fastening the shaft *F* with a nut which should be provided for that purpose on the end of the shaft. After it is fastened in this position, detach the connecting-rod *H*, and with one stroke of the piston a line can be drawn with the pencil *P*. This line will correspond with the vertical line *m t* or *m' t'*, and from it the ports *c* or *e* can be laid off so that the motion-curves will represent the movement of either the steam or exhaust edges of the valve in relation to the ports.

The valve can be placed in its middle position by putting the link in mid-gear and marking on the valve-stem its extreme movement at the stuffing-box of the valve-stem. Subdivide this distance on the valve-stem, and move the subdivision to the point where the marks were made. The valve will then be in the middle of the valve-face, if the valve is set correctly.

(TO BE CONTINUED.)

* The term "boss" is used to imply an enlargement or increased thickness of any part.

Manufactures.

Marine Engineering.

SOME of the Pittsburgh coal operators are about to have built a number of iron barges to carry coal from Pittsburgh to Cincinnati and St. Louis. They will have a capacity of 30,000 bushels of coal each. Iron coal barges are, we believe, a new thing on the Ohio River.

THE Globe Iron Works in Buffalo now employ nearly 1,300 men ; they have three steamships on the stocks, and are finishing two more for the Northern Line and the Lehigh Transportation Company. Four more vessels for the Northern Line are under contract.

THE yacht *Alista*, built for W. O. Wiener, of San Francisco, was launched last week at Bauner & Munn's, Wilmington, Del. It is a novel craft about 30 ft. in length only, 9 ft. beam, and 4 ft. deep, and is designed to take its owner on a solitary trip along the Atlantic Coast to Portland, Me., thence to Panama, crossing the isthmus by rail, and thence up the Pacific Coast.—*Marine Journal.*

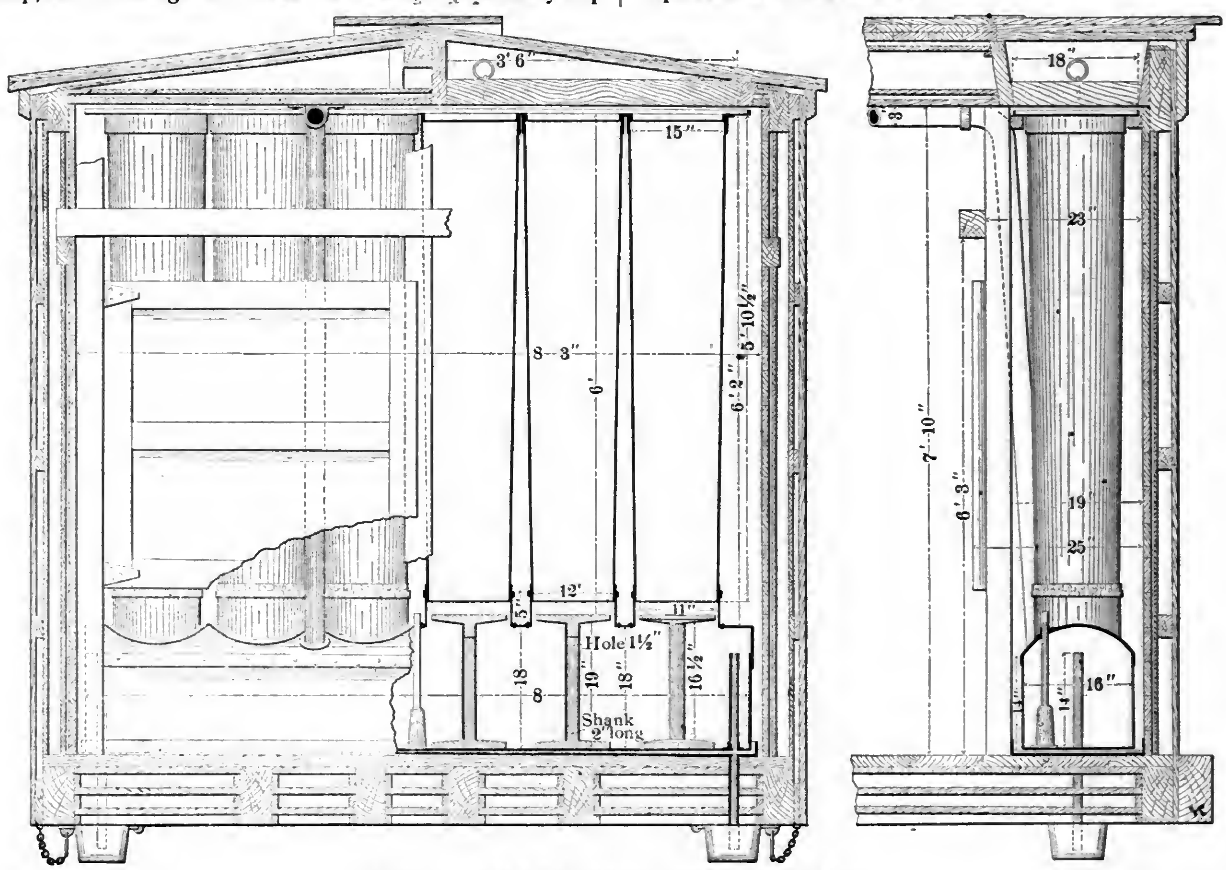
CRAMP & SONS in Philadelphia have taken a contract for a new steamship for the Southern Pacific Company, which is to be 338 ft. long, 42 ft. 8 in. beam, and 31 ft. 8 in. depth of hold, with a gross tonnage of 3,531 tons. She will have triple-expansion engines and be fitted with all improvements in ship building of the present time. Orders for materials will be given out at once, and the construction will begin as soon as the cruiser *Baltimore* is launched, as every available place is occupied by vessels in course of construction at this place.

The Bosmann Refrigerator Car.

THE accompanying illustrations (for which we are indebted to the courtesy of the *Railway Review*) are a cross section and part of a longitudinal section of the Bosmann refrigerator car, and show the leading features of the arrangement. In the end of the car are tapered ice tanks which contain the ice for cooling the car. The purpose of the tapering form is to ensure the constant contact of the ice with the tank and thus almost directly with the air. These are so constructed as to be easily removed and cleaned in a few moments. The tank at the bottom is intended to hold the water from the melting ice, and when this water reaches the top of the overflow pipe it runs off to the trap below.

There is a 3-in. pipe extending from the water tank below to the top of the car, and from thence to the center of the car along under the roof. The object of this pipe, as claimed by the inventor, is to purify the air in the car by bringing it into contact with the water where the impurities are dissolved. The constant pulsations of the water in the water tank cause the air to pulsate in and out by the air holes in the end of the pipe, and thus gradually mix the vitiated air with the air in the interior of the water tank, which has been purified by contact with the cold water. This car has all the advantages of the closed tank cars.

The ice tanks are protected from injury by the doors shown in the cut. The ice is put in at the roof as usual. The tanks made in this form furnish a maximum of cooling surface for a minimum of space occupied at the end of the car. A series of trials of this form of refrigerator car have shown it to meet the expectations of the owners.



THE BOSMANN REFRIGERATOR CAR.

It is claimed that these cars with 3,000 lbs. of ice occupying only 23 in. at each end will carry as low a temperature as some others with 4,000 lbs. of ice taking 36 in. space at each end, and that the weight is less than that of any other refrigerator car. Ten of these cars were recently ordered for the Chicago, Rock Island & Pacific Railroad, and several for the Chicago, Burlington & Quincy.

This device is now in the hands of Mr. Charles F. Pierce, whose office is in the Home Insurance Building, Chicago.

Cars.

THE Cincinnati, New Orleans & Texas Pacific has nearly completed the construction of 200 box cars at the shops at Ludlow, Ky.

THE Anniston shops of the United States Rolling Stock Company are at work on a large order for freight cars for the Anniston & Cincinnati Railroad.

IT is stated that the Canadian Pacific has contracted with the James Crossen Car Works, Coburg, Ont., for the building of 2,000 box cars, and will also build 3,000 at their own shops at Montreal.

THE Lafayette Car Works, Lafayette, Ind., have commenced the delivery of the freight cars recently ordered by the Chicago,

Burlington & Northern. They are of 50,000 lbs. capacity, 34 ft. long.

THE first lot of 300 new 60,000 lbs. ore cars, built at the Louisville & Nashville shops, Louisville, Ky., for the Birmingham Mineral road, were received at Birmingham recently.

THE Terre Haute Car Company in Terre Haute, Ind., is building a number of 60,000 lbs. coal cars for the Chicago, Milwaukee & St. Paul Railway.

THE Pullman shops at Pullman, Ill., have just turned out three very handsome dining cars for the Pennsylvania Railroad vestibule train between New York and Chicago.

THE Car Works of Osgood Bradley at Worcester, Mass., have recently completed eight passenger cars 60 ft. long for the Providence Division of the Old Colony Railroad.

ARRANGEMENTS have been completed to establish new car shops at Bristol, Tenn., and the buildings are now in progress; the shops will employ 200 men, and will begin with an order for 600 box cars.

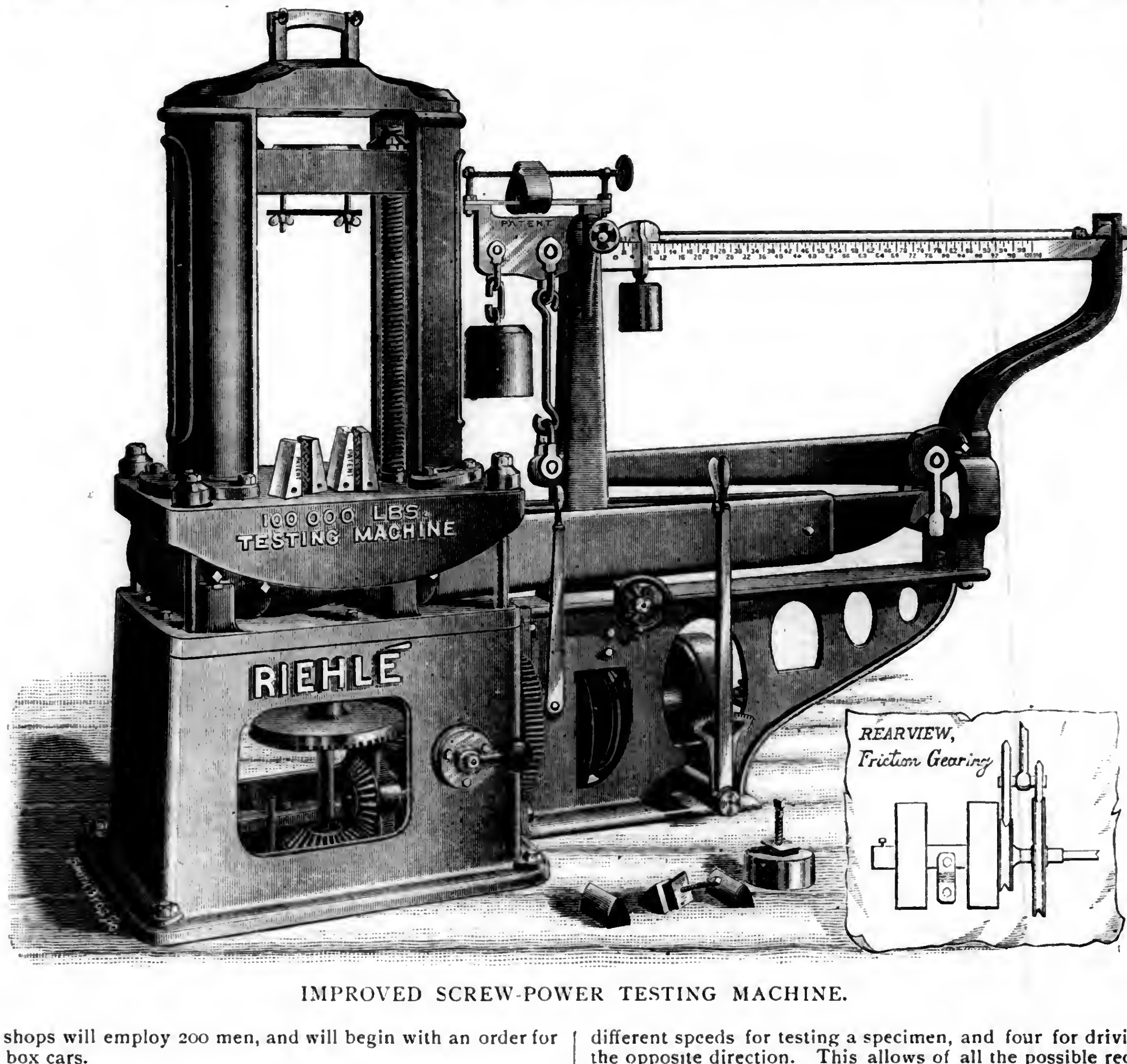
THE John Stephenson Company, Limited, is giving special attention to cable tram cars, and has perfected a system of open and close cars, removing from the car body to the car truck the mechanism of the grip, wheel brake, and track brake, thus providing open and close cars of easy motion, which are claimed to be for quiet and comfort superior to any such vehicles heretofore known.

THE Barney & Smith Manufacturing Company in Dayton, O., are building 5,000 freight cars for the Southern Pacific Company, and 100 box cars for the Mexican Central Railroad. The Company has also an order for 500 box cars of 40,000 lbs. capacity and 500 coal cars of 50,000 lbs. capacity for the Chesapeake & Ohio Railroad. The box cars are to have the Wagner car door.

THE Michigan Car Company in Detroit has recently completed a number of double-deck stock cars for the Chicago, Milwaukee & St. Paul Railway. These cars are 35 ft. long, and are carried on strong iron trucks with swing centers. All have the Westinghouse air-brake equipment, and iron break beams with a sheet-iron truss are placed on both trucks. The Safford draw bar is used. Iron troughs for watering the stock in transit are secured along the sides of all the cars.

Improved Screw-Power Testing Machine.

THE accompanying cut shows a new and improved screw-power testing machine for ascertaining the strength of metals and other materials in tension, transverse, or compression strains, combining the elements of accuracy, speed, and facility of handling. The machine is constructed entirely of iron, steel, and brass, and the levers adjusted to the standard weights of the United States Government. There are no less than six different speeds for testing a specimen, and four for driving in the opposite direction. This allows of all the possible requirements of a wide range of material. There are no loose weights, and a single traveling poise operated by a light hand-wheel registers the strain accurately by means of a vernier.



IMPROVED SCREW-POWER TESTING MACHINE.

The power is applied and reversed by means of a reversing lever, working in conjunction with a notched quadrant, and throwing a friction cone in gear with either open or cross belt as required.

In tests of compression or of material not ductile, where the pressures run up rapidly, there is an arrangement of friction V gears, similar to those of a hoisting engine, which gives an extremely slow and steady revolution of the screw, and enables the operator to weigh with ease and accuracy.

There are new anti-friction bearings of hardened steel balls, which do away with most of the friction so objectionable in the ordinary screw-power machines.

Tools are furnished with the machine for making the various

tests, and there are stops and holders for the grips, etc., as well as bolts and cushions for checking the recoil and keeping the platform in place.

The levers are arranged in tandem style, so that the machine will take up as little room as possible and allow a clear deck for transverse tests.

This style of machine is built in the following sizes: 10,000 lbs., 20,000 lbs., 30,000 lbs, 60,000 lbs., 100,000 lbs., and 200,000 lbs. capacity, and can be built of increased capacity on order.

The dimensions of the 100,000 lbs. machine are: Extreme height, 6 ft.; length, 9 ft. 3 in.; width, 2 ft. 9 in.; its weight is 4,800 lbs. For tensile specimens this machine will take test pieces up to 2 ft. long, 2 in. diameter, 2 in. square or 3 × 1 in. flat bars. Transverse specimens may be from 6 in. to 2 ft. long, and compression specimens up to 2 ft. long and 4 in. diameter. The motion of the pulling head is 2 ft. 4 in.

These machines are made by Riehle Brothers, No. 413 Market Street, Philadelphia, from whom further information can be obtained.

Manufacturing Notes.

THE North Chicago Rolling Mill Company has begun rolling steel beams at its North Chicago mill. The mill started on 6-in. beams, and is now running on 8 and 10-in.

THE Henderson Steel Company has been organized at Birmingham, Ala., and will at once begin to build a blast furnace and Bessemer steel plant. A rolling-mill and a forge will be added hereafter.

THE Duluth Iron & Steel Company has begun to build a blast furnace at Duluth, Minn. The furnace will have two stacks 75 ft. high and 16 ft. bosh.

A NEW company has been organized, and will build a steel plant and rolling-mill for the manufacture of steel tires at Latrobe, Pa. Mr. M. C. Smyth, formerly with the Midvale Steel Company, is at the head of the concern.

THE Dickson Manufacturing Company in Scranton, Pa., recently shipped a full outfit of coal-breaking machinery to a colliery in South Wales; this will be the first machinery of the kind used on that side of the Atlantic.

THE Union Machine Company, in Fitchburg, Mass., recently shipped a large quantity of machinery, including steam-engines, lathes, drills, etc., to Japan.

THE Etna Machine Company in Warren, O., is building an engine of 550 H.P. for the Hubbard Iron Company.

THE Union Iron Works in San Francisco are building two complete sets of pumping engines for the Spring Valley Water Works, and a set of large hoisting engines for a coal-mine in British Columbia.

THE Baltimore & Ohio shops at Mount Clare, Baltimore, are building a number of consolidation engines for the road; and also some heavy passenger engines, which are especially intended for fast running between Baltimore and Washington.

THE Dickson Manufacturing Company in Scranton is building 10 mogul engines with 18 by 24-in. cylinders, and six passenger engines with 17 by 24-in. cylinders and 63-in. driving wheels for the Central Railroad of Georgia.

THE King Iron Bridge & Manufacturing Company is enlarging its works in Cleveland, O., by two buildings each 70 by 600 ft., which will more than double the present capacity of the works.

THE Atlanta Bridge & Axle Company in Atlanta, Ga., is building 22 spans of iron bridge for the Central Railroad of Georgia. This work includes a new drawbridge over the Chattahoochee River.

THE plans for the new bridge over the Mississippi River at Memphis, Tenn., have been submitted to the Secretary of War, and have been referred by him to a board of engineer officers. The western approach will begin nearly three-quarters of a mile from the Arkansas bank of the river, while on the eastern side, where the bluff comes very near the river, the approach will not be more than 300 ft. long. The central span is to be 700 ft., the other span over the channel not less than 600 ft. Even this length does not satisfy the steamboat men, who, in a recent memorial to the Secretary of War, asked that the channel span should be 1,000 ft. long and at least 85 ft. above high water.

THE Safety Car Heating & Lighting Company of New York has been reorganized, with Henry R. Towne, President, and James C. Bayles, Vice-President and General Manager. In addition to the heating system which the Company has already begun to introduce—transferring the heat of steam from the engine to the water circulation in the car and retaining the water-heating stoves, to be used only in cases of emergency—it is preparing several other systems adapted to different kinds of service and not dependent upon the presence of water circulation and stoves in the car. These include direct and indirect steam heating and the circulation of hot air, the normal source of heat in each case being steam drawn from the locomotive. The Company has also acquired exclusive rights under the United States patents of the Pintsch Gas Lighting Company, and has merged that Company's business with its own. The Pintsch system is now employed on a large number of cars in this country and in Europe.

The Naphtha Launch Engines.

A NEW motive power has recently been introduced, and is finding much favor for ship's launches, small boats, and similar purposes, where a very compact engine is required. This is the so-called naphtha launch, and a number have already been built, while many more are under construction. In these boats the naphtha is carried in a tank or magazine, usually placed in the bow and separated from the rest of the boat by a tight bulkhead. This bulkhead is perforated so that the water of the sea or river circulates freely around the tank, keeping it cool. From the tank a feed and two exhaust pipes lead to the machinery, which is contained in another water-tight bulkhead. The boiler consists of a series of spiral coils under which is the steam or vapor chest. The engine has three single acting vertical cylinders the piston rods of which are connected to cranks placed on the shaft at an angle of 120°. The naphtha drawn from the tank to the boiler is used for two purposes, an injector feeding a portion of it to a burner or burners placed under the spiral coil which forms the boiler; the rest of it passes into the boiler and is vaporized, and it is this vapor which is used in the cylinders instead of steam. The coil-boiler presents so large a heating surface that the oil is very quickly vaporized. In some of the boats a pressure of 60 lbs. has been attained in two or three minutes after the burners have been lighted. The makers of this engine claim that 6 per cent. of the naphtha only is required for fuel.

After passing through the cylinders the vapor or exhaust is condensed in the exhaust pipes, which are carried under the bottom of the boat, and returns to the reservoir again as a liquid, the loss being comparatively small. The supply is regulated by valves and is kept up by an air-pump. To start the engine all that is necessary is to start this air-pump by hand, light the burners, and a very few strokes of the pump will give a sufficient supply to heat the boiler and vaporize the naphtha.

It is claimed that this power is very cheap; its economy, however, is not fully established, but the small space required for the machinery, and the ease with which the engine can be regulated, present so many points in its favor, for the purpose in which it has been used, that economy is a minor consideration. The naphtha engine can be applied to many small boats and launches where a steam-engine and boiler would take entirely too much room. A very similar device has also been introduced in England, where it is known as the "petroleum spirit engine." The arrangements in these differ somewhat from those so far adopted in this country, but the general principle is the same.

Proceedings of Societies.

American Society of Civil Engineers.

AT the regular meeting of June 6 the Secretary announced the death of William L. Baker, a member. The usual memoir was ordered to be prepared. The Secretary further announced that the circulars in relation to the Annual Meeting had been issued to members, and that most of the members from New York and vicinity would go to Milwaukee together in a special train.

A paper by Mr. James Moore was read giving his experience as engineer of the first locomotive built by Baldwin for the Philadelphia, Germantown & Norristown Railroad.

Mr. Thompson presented the Society with a photograph of the *De Witt Clinton*, the first locomotive on the Mohawk & Hudson Railroad.

The following gentlemen were elected:

Members: William Henry Baldwin, Yonkers, N. Y.; Will-

iam Murray Black, Captain of Engineers, U.S.A., St. Augustine, Fla.; Dexter Brackett, Boston, Mass.; Francis Smith Burrowes, Lancaster, Pa.; Willis Chipman, Brockville, Can.; Solomon Lefevre Deyo, Harrison, N. Y.; Henry Goldmark, Kansas City, Mo.; Lewis Muhlenberg Haupt, Philadelphia, Pa.; Joseph Warren Hoover, Kansas City, Mo.; Lewis Blake Jackson, Chicago, Ill.; Cassius William Kelly, New Haven, Conn.; Alexander Macomb Miller, St. Louis, Mo.; Richard Montfort, Louisville, Ky.; John Frank Stevens, Marquette, Mich.

Associate: Louis de Coppet Berg, New York City.

Juniors: Andre Pierre Tachard, New York City; Job Tuthill, Ionia, Mich.

THE Annual Convention was to be held in Milwaukee, beginning Thursday, June 28. Meetings for discussion and for the transaction of business were provided for on June 28, 29, 30, and July 2; the week from July 2 to July 7 will be occupied by excursions and visits to points of engineering interest in the Northwest.

Besides the papers published during the past year and open to discussion, the following new papers will be presented at the Convention:

Improvement of Rivers on the Atlantic Coast: William P. Craighill.

High Walls or Dams to resist the Pressure of Water: James B. Francis.

Maintenance of Railway Structures: Henry D. Blunden; also a general discussion on this subject.

Formulas for the Weights of Bridge Trusses: A. J. Du Bois.

An Investigation to Determine the Strains in a hollow Cast-Iron Disk, Cooled from the Interior: G. Leverich.

English Railroad Track: E. E. Russell Tratman.

An Automatic Waste Weir: A. D. Foote.

Some Facts in relation to Friction, Waste and Loss of Water from Mains: Charles B. Brush.

In addition to these papers reports were presented by a number of standing committees, including those on Uniform Time; on the Relation of Railroad Wheels and Rails; on Cements and Mortars; on Engineers on Public Works.

Boston Society of Civil Engineers.

A REGULAR meeting was held in Boston, May 16, President Fitz Gerald in the chair, 59 members and 17 visitors present.

Messrs. Edgar S. Dorr, Boston, and Edmund B. Weston, Providence, were elected members of the Society. Four names were presented for membership.

Mr. William E. McClintock, City Engineer of Chelsea, Mass., read a paper on the Construction and Ventilation of Small Pipe Sewers, giving his experience with small sewers in that city. Mr. F. P. Stearns, Engineer of the Massachusetts State Board of Health, followed with an account of the use of small sewers in other sections of the country. The subject was further discussed in written communications from Mr. F. Floyd Weld, City Engineer, Waterbury, Conn.; Mr. G. T. Nelles, City Engineer, Leavenworth, Kan.; Mr. A. R. Sweet, Engineer and Superintendent of Sewers, Pawtucket, R. I.; Mr. W. B. Pierce, Borough Engineer, Stamford, Conn.; and Mr. George A. Kimball, late City Engineer, Somerville, Mass.

Engineers' Club of Philadelphia.

AT the regular meeting in Philadelphia, May 19, Mr. William F. Sellers presented an illustrated paper on the Galloway Boiler. Mr. Henry G. Morris opened the discussion of How Should the Connections be Made between the Parts of Water-tube Boilers? which was participated in by Mr. John Overn of the Bureau of Boiler Inspectors, Philadelphia (visitor), and Messrs. M. R. Muckle, Jr., John L. Gill, Jr., J. E. Codman, Washington Jones, and others of the Club. The discussion took a wide range, covering much detail—the importance, for safety, of avoiding erroneous innovations in design and construction being specially emphasized.

Mr. Henry G. Morris exhibited, in operation, and described the Grove Electric Meter.

AT the regular meeting of June 2, Mr. A. Marichal read an elaborate paper on the Public Health of Cities and Towns, going very extensively into the subjects of water-supply, drainage, paving, street cleaning, public conveyances, and dwellings; this was discussed by Messrs. Redway, Brown, and Howard Murphy.

The Secretary presented for Mr. William S. Sheaffer notes on the Coal Deposits of Sonora, Mexico.

The Secretary presented from Mr. A. W. Sheaffer a photograph and description of the Stripping of the Mammoth Coal-bed at Shenandoah, Pa.; and also a note on Electric Haulage in Coal Mines.

The Secretary presented for Mr. G. W. Jones descriptions of a new valve motion in which the cut-off and reversing gear are worked by adjustable eccentrics.

Mr. Howard Constable presented a description of the Montague Street Electric Railroad and Terminal Station in Brooklyn, N. Y., which was discussed by members

Professor L. M. Haupt presented an outline of a study entitled The Great Transportation Areas of the United States, in which he determined the locus of the points from which the cost of transportation to tide-water would be the same whether carried by rail entirely or partially by river and rail, or by lake, canal, and railroad. It resulted in a division of the country into five grand areas, of which the natural outlets were the Atlantic, Gulf and Pacific Coasts, the Mississippi River, and the Great Lakes. The ocean rate being but about one-sixth that by rail, it was shown how important it was to reach tide-water by the line of least resistance. The Northern and Southern or Lake and Gulf routes were briefly contrasted, and the importance of creating a deep water outlet for the grand railroad empire of the Southwest was pointed out as being one of the most important of the transportation questions of the present and the future. The extent of territory tributary to the Gulf, as the nearest point for Eastern traffic, was estimated at about 1,000,000 square miles. Attention was called to the proposed Deep Water Convention, to be held at Fort Worth, July 10, and it was stated that the present available depth is but 12¾ ft., which is found on the bar at Galveston.

Professor Haupt also presented drawings showing a method of Building Tunnels under Rivers.

Engineers' Club of Cincinnati.

THE organization heretofore referred to in Cincinnati has been completed, and will be known as the Engineers' Club of Cincinnati. Civil, military, mining, mechanical, hydraulic, and electrical engineers will be eligible to full membership; scientists, managers of works, and others interested may become associate members.

The organization was completed at a meeting held May 16. The new Club starts with 40 members, and has chosen the following officers: President, Colonel William E. Merrill, U.S.A.; Vice-President, G. Bonscaven; Secretary, Russell Hinman; Directors, G. B. Nicholson, Latham Anderson, and J. Foster Crowell.

THE first regular meeting was held in Cincinnati, June 6. Professor H. T. Eddy explained and described a new formula which he had devised for reducing the labor of calculating strains in girders, where the moving load is unevenly distributed, by substituting an equivalent uniform load. He showed by diagram the polygon for the actual load and the parabola which is its nearest equivalent, and stated that his formula would generate the parabola in question with an error in the maximum stress not greater than 5 per cent., mainly on the side of safety.

Western Society of Engineers.

A REGULAR meeting was held in Chicago, June 6. Lewis D. Jackson was elected a member. The Secretary reported that there would be a deficit on the present basis at the close of the year, and was instructed to collect the additional dues, as authorized by the by-laws. The President reported that the trustees had not yet matured any plan as to the future policy of the Society, and would report on the matter at the next meeting; he also stated that the Committee on Highway Bridges had taken action in carrying out the instructions of the last meeting. Considerable discussion occurred in regard to the functions of State engineers in the several States, and upon the general question delegated to the Committee.

Upon motion of Mr. Liljencrantz, a Committee upon Employment was ordered to consider and report at the next meeting some plan, and the necessary rules for carrying it into effect, for receiving and taking action upon applications for positions or for professional assistance from members of the

Society. After some discussion Messrs. Liljencrantz and Parkhurst were appointed as a committee.

The death of William L. Baker, a member, was announced. A committee was appointed to report suitable action on the death of Mr. Baker and Mr. Charles Lattimer.

The Secretary read a paper by Alva M. Van Auken on Classification of Material in Railroad Construction, and a supplementary paper upon the Commissary in Railroad Field Parties. The paper was discussed at length by Messrs. Weston, Gottlieb, Parkhurst, Liljencrantz, and others. It was ordered that the paper be held until next meeting for further discussion, and that the remarks be put in writing for publication.

Engineers' Club of St. Louis.

A REGULAR meeting was held in St. Louis, May 16. William T. Gould was elected a member.

Mr. Charles F. White then read a paper on the Failure of a Firmenich Boiler, which occurred by the Plant Flour Mills, in St. Louis. The construction of the boiler was described in detail, and the writer considered the failure due to faults in design and the absence of sufficient allowance for expansion. This paper was discussed. Mr. Louis Stockett then read a paper on a Well-Ventilated Mine, which was also discussed.

The Committee on National Public Works reported in favor of the general principles of the Cullom bill, with some amendments After discussion the report was adopted.

A REGULAR meeting was held in St. Louis, May 30. The special Committee on Highway Bridges reported in favor of co-operation with other engineering clubs to secure better construction of such bridges and State inspection. The report was accepted, and Messrs. R. Moore, C H. Sharman, and A. W. Hubbard were appointed a committee to carry out its recommendations.

Mr. R. E. McMath then read a paper on The Water-Way between Lake Michigan and the Mississippi River, by way of the Illinois River. The author having been in charge of the Government work on the Illinois River for some years, was able to treat the question in the light of experience. He referred to canals in general, and gave special attention to the various schemes connected with the Illinois River, as well as the Hennepin Canal and the complications due to the Chicago drainage. The following committees were chosen: Finance, J. B. Johnson, R. E. McMath, Robert Moore, W. B. Potter, and E. D. Meier. Correspondence, J. B. Johnson, R. E. McMath, E. D. Meier, F. E. Nipher, and C. M. Woodward. The meeting then adjourned.

Engineers' Club of Kansas City.

A REGULAR meeting was held in Kansas City, June 4. Albert N. Connett and Bolton W. De Courcy were chosen members, and Victor M. Witmer an associate member. The Secretary reported several additions to the library; also letters from a number of engineers' associations in relation to bridge reform. Most of them expressed a desire to co-operate. A committee was appointed to arrange for an excursion of the Club sometime during the summer.

Mr. Breithaupt read a paper on the crossing of the Chicago, Santa Fé & California Railroad over the Missouri Pacific and the Chicago & Alton tracks near Rock Creek. The bridge has a riveted pony truss, and is interesting on account of the necessity of keeping clear of the several tracks, the crossing being on a skew. The paper was discussed by a number of members present chiefly with reference to the number and spacing of the stringers and the effect of rigidity in bridge superstructures.

New England Water-Works Association.

THE Seventh Annual Convention met in Providence, R. I., June 13, with a large attendance, and was called to order by President Darling, who made a brief address. The Treasurer's report showed receipts of $2,585 and a balance on hand of $883.

After the opening proceedings papers were read upon Soils from which Supplies of Water may be Obtained by Driven Wells by Phineas Ball, of Worcester, Mass., and on a Water Level Indicator for Reservoirs or Tanks by W. P. Whittemore, of North Attleboro, Mass. These papers were followed by a discussion on the Best Way to Limit the Use and Weight of Special Castings.

At the afternoon session Professor J. E. Denton, of the Stevens Institute of Hoboken, presented a series of lantern views showing the Problems Involved and Methods Employed in Building the New Croton Aqueduct, New York City.

On the following day papers were read on the Aeration of Water by Natural Canals and Low Dams by S. E. Babcock and on Covered Reservoirs by Charles H. Swan, of Boston. There were discussions on both papers. A third paper on Tests by Tubular Wells was read by W. C. Boyce, of Worcester, Mass. The following officers were chosen for the ensuing year:

President, Hiram Nevons, Cambridge, Mass. Vice-Presidents, Dexter Brackett, Boston; William B. Sherman, Providence, R. I.; V. C. Hastings, Concord, N. H.; S. S. Coolidge, Bellows Falls, Vt.; George P. Westcott, Portland, Me.; Charles E. Chandler, Norwich, Conn. Secretary, R. C. P. Coggeshall, New Bedford, Mass. Treasurer, Albert S. Glover, West Newton, Mass. Senior Editor, Professor George F. Swain, Massachusetts Institute Technology, Boston. Junior Editor, Walter H. Richards, New London, Conn. Executive Committee, Frank E. Hall, Quincy, Mass.; William R. Billings, Taunton, Mass.; Edwin Darling, Pawtucket, R. I. Finance Committee. George E. Batchelder, Worcester, Mass.; James H. Hathaway, New Bedford, Mass.

The afternoon was spent in looking over the water-works of Providence.

On the third day, Thursday, a paper was read by Mr. S. E. Babcock on the Use of Relief Valves in Distribution Systems. Mr. L. F. Rice read a paper on Testing Water Meters.

Mr. W. B. Sherman, from the Committee on Blue Prints, reported that 22 members had contributed blue prints, varying from a single sheet to 100 duplicates; complete sets were given to those who had contributed, and the balance were distributed among the members.

It was resolved to hold the next meeting at Fall River, Mass. After passing the regular resolutions of thanks, etc., the Convention adjourned. On the fourth day, Friday, the members visited Valley Falls by invitation, and then took a trip down the Bay to Rocky Point, where a Rhode Island clam-bake was served.

Montana Society of Civil Engineers.

AT the regular monthly meeting in Helena, Mont., May 19, George T. Wickes was chosen a member; Mr. J. S. Keerll was appointed to represent the Society of the Board of Managers of the Association of Engineering Societies.

Mr. E. H. Beckler read a paper on Railroad Location, which was discussed by the members present; further discussion of the paper was postponed until the next meeting.

Civil Engineers' Association of Kansas.

AT the May meeting of this Association important additions to the library were made. Several communications were received requesting the Association to urge the appointment of a State Inspector for Highway Bridges.

At the June meeting the subject of Bridges was discussed. Several papers were presented by members.

American Institute of Electrical Engineers.

THE Annual Meeting was held in New York, May 15. The Secretary read his report, showing that there are now 322 members. The Institute has secured an office in the city, and has under consideration arrangements for providing permanent quarters.

Reports were also presented by the Treasurer, the Auditing Committee, and the Committee on Wire Gauge. Several papers were read by members, and the new President of the Institute made a brief address. The following officers were chosen for the ensuing year: President, Edward Weston; Vice-Presidents, E. Thomson, F. R. Upton, and T. C. Martin; Secretary, Ralph W. Pope; Treasurer, George M. Phelps, Jr.

American Association of Railroad Chemists.

A MEETING of this Association was held in Cleveland, O., May 16, with a large attendance of members and of representatives of manufacturing companies. Among the subjects discussed were: Classification of Lubricating Oils; Flashing and

Burning Tests ; Thermometers ; Viscosity and Specific Gravity Tests ; Cold Tests, etc.

The following officers were elected : President, W. D. Gregory, New York, Lake Erie & Western ; Vice-President, W. L. Brown, Chicago, Burlington & Quincy ; Secretary and Treasurer, G. W. Davidson, Chicago & Northwestern

Association of Railroad Accounting Officers.

THE Committee of fifteen provided for by the convention of railroad accounting officers which met at Washington, March 28, for the purpose of considering the question of the formation of an association, met at Chicago, May 30. After mature consideration of the subject the Committee came to the unanimous conclusion that such an association was desirable. This belief appears to be shared in very generally by the railroad accounting officers of the country, so far as it is possible to judge from the great number of communications received by the Committee on the subject. The Committee have accordingly called a convention of railroad accounting officers to be held at the Hotel Brunswick, New York City, July 25, at 11 o'clock, for the purpose of adopting a constitution and by-laws and electing officers thereunder, and they invite the railroad companies to send representatives thereto. They not only invite the attendance of the representative accounting officer of each company, but they suggest to the railroad companies that they send representatives of the various departments of accounts, so that the Association may have the benefit of their advice and experience.

Master Car-Builders' Association.

THE Master Car-Builders' Association began its twenty-second annual convention at the Thousand Island House, Alexandria Bay, N. Y., on Tuesday, June 12. The convention was called to order by President McWood, who delivered a brief opening address. The reports of the Secretary and Treasurer were then presented, and the usual committees on nominations, auditing, etc., were appointed.

Messrs. D. H. Neale, C. A. Park, and F. W. Webb were elected associate members.

The report on Standard Appliances for the Safety of Trainmen was then read ; it was followed by a discussion, at the close of which the recommendations made were ordered submitted to letter-ballot.

The Committee on Journal Lubrication then presented its report. This was followed by the report of the Committee on Uniformity of Interchangeable Parts of Cars. On this there was a brief discussion.

SECOND DAY.

The second day was devoted entirely to the discussion of the Rules Governing the Condition and Repairs of Freight Cars for the Interchange of Traffic. This discussion took a wide range and resulted in many amendments to the rules, with the object of making them more clear and explicit on doubtful points. The discussion on the rules was not completed until Thursday morning.

THIRD DAY.

After finishing up the revision of the rules, the Committee on Steam Heating presented its report. This was discussed at some length, and it was finally resolved that a new committee should be appointed to select two couplings for steam pipes, to be submitted to letter-ballot for adoption as standards.

The subject of a Standard Axle for 60,000 lbs. Cars was brought up and a new letter-ballot was ordered.

The Committee on Continuous Brakes for Freight Trains presented its report, as follows :

"In our report to the convention last year the main conclusion we arrived at was that the best type of brake for freight service was one operated by air, and in which the valves were actuated by electricity. Since that time your Committee has not made any further trial of brakes, but the aspect of the question has been much changed by the remarkable results achieved in non-official trials which have taken place in various parts of the country, and have been witnessed by many of the members of this Association. These trials show that there is now a brake in the market which can be relied on as efficient in any condition of freight service.

"The present position of the freight train brake is briefly as follows :

"First—Brakes can be, practically speaking, simultaneously applied without electricity throughout a train of 50 freight cars.

"Second—Other inventors are working at the problem of making an air brake which will be rapid in action and suitable for service on freight trains. We also understand that inventors are working at buffer and electric friction brakes, but we have no reason to hope that brakes on these principles can successfully compete with air brakes.

"In view of these conditions your Committee does not recommend the adoption of any particular brake, but considers that a freight train brake should fulfill the following conditions :

"First, it shall work with air of 70 lbs. pressure. A reduction of 8 lbs. shall set the brakes lightly, and a restoration of pressure shall release the brakes.

"Second, it shall work without shock on a train of 50 cars.

"Third, it shall stop a train of 50 empty freight cars when running at 20 miles per hour, within 200 ft. on a level.

"Fourth, when tried on a train of 50 cars, it shall maintain an even speed of 15 miles an hour down a grade of 53 ft. per mile without variation of more than 5 miles per hour above or below that speed at any time during the descent.

"Fifth, the brake shall be capable of being applied, released, and graduated on the whole train by the engine, or without any assistance from the brakemen or conductor.

"Sixth, the hose coupling shall couple with the present Westinghouse coupling.

"We recommend that all freight cars fitted with such a brake shall be marked 'Air brakes' on each side of the car, near the top. The Committee further recommends the use of iron or steel brake beams, and that the subject of the best form and proportion of brake gear and the selection of a standard solid brake shoe for use with metallic brake beams should be entrusted to a committee appointed for the purpose."

This report was received, and it was ordered that a Committee on Brake Gear be appointed, as recommended.

The Executive Committee presented its final report on Car Couplers. After some discussion it was ordered that the length of draw-bar, size of dead-blocks, etc., as proposed by the Committee, be submitted to letter-ballot.

Cleveland, Lake George, and Niagara Falls were named as places for holding the next convention, the Executive Committee being empowered to choose one of the three, after consultation with the Master Mechanics' Association.

The following officers were then chosen for the ensuing year : President, William McWood ; Vice-Presidents, John W. Cloud, E. W. Grieves, and John S. Lentz ; Treasurer, John Kirby.

Master Mechanics' Association.

THE annual convention of this Association was held, June 19, at Alexandria Bay, N. Y., where the Master Car-Builders had met the preceding week. President Setchel occupied the chair, and there was a very good attendance.

The subjects to be reported on and discussed were : Relative Proportion of Cylinders and Driving Wheels to Boilers ; Guides ; Extension Smoke-boxes and Brick or other Fire-box Arches ; Springs and Equalizers ; Tires, and the Best Thickness for them ; Purification and Softening of Feed-water ; Prevention of Dangerous Escape of Live Coal and Sparks from Ashpans ; Tender Trucks ; Traction Increasers in Connection with Over-cylindered Engines ; Magnetic Influence of Iron and Steel in Locomotives on the Watches of Engine Runners.

The Committee on Amendments to the Constitution also submitted a report.

General Managers' Association of Chicago.

THE Committee (E. T. Jeffery, A. Kimball, and Henry B. Stone) to whom the question of a uniform freight car coupler was referred by this Association, have made the following report :

"The Committee appointed at the meeting of the General Managers' Association of Chicago, held November 26, 1887, beg to say that they have carefully considered the matter referred to them, and have had a personal interview with Messrs. Forney and Wall, of the Committee of Master Car-Builders' Association, on Couplers, and your Committee are much impressed with the careful manner in which they have considered the matter, and their thorough investigation and experiments.

"Your Committee therefore recommend to the Association :

"1. The adoption of what are now known as vertical hook couplers.

"2. That all such couplers be made in accordance with the Master Car-Builders' type as to size and proportions, so as to couple with each other, and be interchangeable with each other.

"Your Committee make their recommendation in this form as, after their examination, they are not yet prepared to recommend as clearly better than all others, any individual coupler, of which there are a number which are, or can be made, interchangeable with the Master Car-Builders' type.

"Your Committee find that there are conflicting claims in regard to the patents of many of these couplers, and would remind the Association of the necessity of carefully examining these before deciding on the use of any individual coupler. Those members of the Association who are also members of the Western Railroad Association can obtain full information on this point by addressing Mr. George Payson, the General Counsel of the Western Railroad Association."

OBITUARY.

HENRY C. BRUNDAGE, the architect and designer of the original Portage Bridge on the Erie Railroad, died at Dunkirk, N. Y., May 23.

LIEUTENANT-COLONEL LORENZO SITGREAVES, who died in Washington, May 14, had been on the retired list for over 20 years. From 1838, when he graduated from West Point, until his retirement he served in the Engineer Corps with credit, and was engaged in many important surveys and other works.

JOHN B. HOFF died at Elkton, Md., May 28, in his 84th year. He assisted in laying out and building the Newcastle & Frenchtown Railroad in Delaware, which was the first in the world to use steam power to convey passengers, and was all his life more or less engaged on the construction and operation of railroads.

W. R. KUTTER, author of the well-known "Kutter's formula" for the mean velocity of water flowing in open channels, and well known otherwise as an engineer and technical writer of much ability, died suddenly at his home in Berne, Switzerland, May 6. Much of his time had been devoted to theoretical investigation, and at the time of his death M. Kutter had nothing but his salary as Assistant City Engineer of Berne.

WILLIAM L. BAKER, Superintendent and Engineer of the Detroit Bridge & Iron Works, died at his residence in Detroit, May 28, aged 37 years. Mr. Baker graduated at the Rensselaer Polytechnic Institute in 1871, and very soon afterward became connected with the Detroit Bridge Works, and has remained with that Company ever since. He was known as an active man and a capable bridge engineer. His health has been failing for some time past.

DAVID BEACH GRANT, who was for a number of years the Manager of the Grant Locomotive Works in Paterson, N. J., died in Washington, June 16, aged 50 years. He was a son of the late Oliver De Forest Grant, the chief owner of the works, and had full charge of their operations for some ten years. Although not a mechanic by training, he had a remarkable aptitude for the business, and much good work was done under his charge. After leaving the Grant Works he was for a time engaged in manufacturing forgings and car-axle, but for several years past he has not been in any business.

ARTHUR A. HOBART, who died in Boston, May 23, aged 56 years, had seen much and varied service on railroads. Beginning as a conductor on the Chicago & Northwestern Railroad, he was in 1870 appointed Superintendent of the Milwaukee and Wisconsin divisions of that road. From 1876 to 1879 he was Assistant General Superintendent of the Chicago, Burlington & Quincy, resigning in the latter year to accept the position of Superintendent of the Troy & Boston road. He was afterward for a short time Superintendent of the Boston & Lowell, and in 1882 he returned to the West and accepted the superintendency of the Chicago Division of the Wabash, St. Louis & Pacific. His last position was Superintendent of the Eastern Division of the Chicago, St. Paul, Minneapolis & Omaha, which he resigned some two years ago on account of ill health and removed to Boston. In the West Mr. Hobart had a high reputation for his ability in handling train service on a crowded road.

PROFESSOR ROLAND DUER IRVING died at Madison, Wis., May 30, aged 41 years. He was born in New York City, and was a graduate of the Columbia College School of Mines in the class of 1869. The degree of Ph.D. was conferred on him by that institution in 1879. After serving as assistant in the Ohio Geological Survey, he was elected in 1870 Professor of Geology, Mining, and Metallurgy in the University of Wisconsin, and he has since retained that position. From 1873 till 1879 he was Assistant State Geologist of Wisconsin. In 1880–82 Professor Irving was one of the United State census experts, and in 1882 he was placed in charge of the Lake Superior Division of the United States Geological Survey. He was a member of various scientific societies, and contributed important papers to their transactions, besides publishing valuable official reports on geological subjects. Professor Irving was recently asked by Mr. Powell of the United States Survey to attend a scientific conference to be held in Europe this summer, and was considering the matter when taken down by his last illness.

ALFRED DURAND-CLAYE, who died in Paris, April 27, aged 42 years, was a graduate of the Ecole Polytechnique and the Ecole des Ponts et Chaussées.

In 1866 he was attached to the city service of Paris as Engineer of the third rank, and became a colaborer with M. Alphaud and a colleague of Couche, Bartet, and André. He was always an earnest advocate of the method of sewerage known as "Tout à l'égout," so long opposed in Paris. With M. Mille he established the sewage irrigation system at Gennevilliers and made it successful. He believed it would disprove all the agricultural, hygienic, and practical objections that were made to it. He had planned to take another portion of the Paris sewage to Achères, and though he did not live to see the realization of this project, his associates zealously continue the work.

The name of M. Durand-Claye has been connected with all the great subterranean highways of Paris that have been executed within a score of years. He had opponents in the special field of sanitary improvement to which he was devoted, but no enemies, and the numerous publications in which he has grouped the field experiments at Gennevilliers and his studies on the sewers of Paris and of other great European cities are equally consulted by his allies and antagonists.

M. Durand-Claye was Chief Engineer of the Drainage System of Paris, Ingenieur en Chef des Ponts et Chaussées, Professor in l'Ecole Nationale des Ponts et Chaussées and in l'Ecole des Beaux-Arts, and a member of many leading technical societies, and an officer of the Legion of Honor.

PERSONALS.

H. G. TAYLOR has been appointed Superintendent of the Calumet & Chicago Canal & Dock Company's works.

WILLIAM M. GREENE has been appointed General Manager of the Cincinnati, Indianapolis, St. Louis & Chicago Railroad.

COLONEL W. H. PRYOR, of Lynchburg, Va., is now Chief Engineer of the Atlantic, Atlanta & Great Western Railroad.

JAMES OWEN has been appointed Engineer and Superintendent of the Montclair Water Company's works at Montclair, N. J.

J. R. RENIFFE has been appointed Master Car-Builder of the Flint & Pere Marquette Railroad, with office at East Saginaw, Mich.

J. J. CASEY has been appointed Superintendent of Motive Power of the Louisville, New Orleans & Texas Railroad, with office at Memphis, Tenn.

A. E. SWAIN, of Kansas City, Mo., has been appointed Assistant Chief Engineer of the Mexico Pacific Railroad, a projected line from Hermosillo to Mazatlan.

WILLIAM GORSTANG has been appointed Superintendent of Motive Power of the Chesapeake & Ohio Railroad. He was recently on the Cleveland, Columbus, Cincinnati & Indianapolis road.

COMMANDER R. D. EVANS, U.S.N., has been relieved from duty as Secretary of the Lighthouse Board, and has been ordered to the New York Navy Yard to take charge of the construction of the armored cruiser *Maine*.

H. N. BURFORD has been appointed Superintendent of Motive Power and Rolling Stock of the Texas & Pacific Railroad, with headquarters at Marshall, Tex., to fill the vacancy occasioned by the resignation of Jacob Johann.

HENRY TREGELLES has been appointed Master Mechanic of the Susquehanna Division of the New York, Lake Erie & Western Railroad. He has for some time had special charge of the air brakes and brake service on the road.

GEORGE W. CUSHING has resigned his position as Superintendent of Motive Power of the Philadelphia & Reading Railroad. He has been on the road but a short time, having gone there from the Northern Pacific less than a year ago.

HERMAN WINTER has resigned his position as Consulting Engineer of the Southern Pacific Company (Morgan Steamship Line) on account of ill health. Mr. Winter has had charge of the design and construction of a number of large steamers for the company.

ASSISTANT ENGINEER WILLIAM J. BAXTER, ENSIGN CHARLES H. HEWES, and ENSIGN WASHINGTON T. CAPPS have been appointed Assistant Naval Constructors by the Secretary of the Navy. The three officers have been for some time studying shipbuilding in Scotland.

GEORGE RICHARDS has been retired from the position of Master Mechanic of the Boston & Providence Railroad, owing to the lease of that road by the Old Colony Company. He has held the office since 1870, and had been 39 years on the road, beginning as a machinist in the shops in 1849.

CAPTAIN EDWARD BURGESS, of Boston, has been appointed Chairman of the Board to consider and report on life-saving appliances by the Secretary of the Treasury. He is very well qualified for the position by his experience in that direction. Captain Burgess is also well known as the designer of the famous yachts *Puritan* and *Mayflower*.

J. A. L. WADDELL and W. D. JENKINS have formed a partnership and will hereafter conduct business together as consulting and civil engineers, having their offices at No. 118 West Sixth Street, Kansas City, Mo. Both gentlemen have had wide experience in designing and constructing bridges and similar structures. Mr. Waddell will attend specially to superstructure, and Mr. Jenkins to substructure and foundation work.

GENERAL W. B. FRANKLIN has been appointed by the President Commissioner-General of the United States to the Paris Exposition of 1889, and has accepted the position. General Franklin graduated from West Point in 1843, and served in the Army from that time until 1866, reaching the rank of Colonel of the 12th Regular Infantry and Major-General of Volunteers. Since 1866 he has been head of the Colt Fire-Arms Manufacturing Company, at Hartford, Conn. Mr. Somerville P. Tuck, of New York, will be the Assistant Commissioner-General under General Franklin.

GEORGE B. MALLORY, the well-known marine engineer, has been appointed Consulting and Chief Engineer of the Southern Pacific Company's steamship line (the Morgan Line) from New York to New Orleans and Gulf ports. Mr. Mallory will have charge of the design and construction of all new steamers for the line.

Mr. Mallory has also been appointed Consulting Engineer of the Keystone Bridge Company of Pittsburgh.

THE following changes in the Engineer Department of the United States Navy are announced: CHIEF ENGINEER J. W. MOORE is ordered from New York to the Mare Island (Cal.) Navy Yard, replacing CHIEF ENGINEER GEORGE F. KUTZ, who is ordered to duty as Inspector of Machinery at the shipyard of William Cramp & Sons, Philadelphia. He relieves there CHIEF ENGINEER H. W. FITCH, who is ordered to duty at the Naval Academy at Annapolis, where he replaces CHIEF ENGINEER EDWARD FARMER, who is ordered on sea service. CHIEF ENGINEER JOSEPH TRILLEY is ordered from the receiving ship *Wabash* to the Portsmouth Navy Yard, relieving CHIEF ENGINEER W. B. BROOKS, who is placed on waiting orders.

NOTES AND NEWS.

The Typewriter.—In 1829 drawings and specifications covering the invention of a typewriter, which closely resembles the construction of the modern typewriter, were deposited at the United States Patent Office, the certificate of registration being signed by Andrew Jackson. The earliest patent of all appears to be one filed in the British Office in 1714, No. 395.

The Stampede Tunnel.—The headings in the Stampede Pass Tunnel on the Cascade Division of the Northern Pacific Railroad met on May 3, and trains ran through it early in June. This tunnel was begun two years ago, and is among the longest in the world. It is 9,850 ft. long in all and is 16 ft. wide by 20½ ft. high in section. The rock throughout was a gray conglomerate basalt, of medium hardness, but slacking and scaling on exposure to air, rendering timbering necessary. The contractor was Wilson Bennett. The west end approach consisted of open cut through trap rock, while the east end enters the tunnel by crossing a creek immediately under a cataract, which has a fall of 160 ft. Before crossing this creek the track is made by cutting a heavy ridge or slide of earth and loose rock. These two approaches contained in the aggregate upward of 30,000 cubic yards of material, most of which was solid rock, which had to be blasted.

The St. Clair River Tunnel.—After a long period of waiting, work on the proposed tunnel under the St. Clair at Port Huron is again actively under way. The developments so far are most satisfactory, the measurement showing more than the required thickness of clay everywhere, with no fault or break discoverable. The shoe on the American side was successfully put in place recently, and the shaft is now being excavated.

On the Canadian side good progress is being made, and the brick lining has been lowered by successive drops of from 4 to 8 ft. each, until it is now half way or so to bed-rock. A blower for forcing air down the shaft and the electric light plant of the machinery will soon be in place.

The tunnel is to be built by a separate company, but will be used by the Grank Trunk Railway trains.

Snow on the Gothard Railway.—On February 15, after a prolonged fall of snow, an avalanche fell blocking up the Gothard Railway and causing the death of five workmen. About 3 o'clock in the day an avalanche had fallen directly in front of the southern entrance to the covered way near Wasen. Workmen were sent to clear the line, but they had not been thus employed for more than one-half hour before a fresh avalanche rushed down, this time blocking up the northern entrance and covering the unfortunate workmen to a depth of several feet. The snow was forced up the gallery for a distance of 50 ft., while the débris from the avalanche extended nearly 350 ft. further, and was so compact that it was necessary to use pick-axes in removing it. The rescuing party succeeded in finding one of the workmen alive, though the other five were all dead. It is stated that the severity of the avalanches in this district is due to the gradual deforesting of the hill slopes.

Locomotives on the Canal.—About two weeks since the London & Northwestern Railway officials made an experiment as to drawing canal boats with a locomotive. A track of 18-in. gauge and about a mile in length had been laid along the canal bank. On it was placed a small locomotive. When steam was up two boats were attached by ropes to the locomotive, which drew them along easily at the rate of seven miles an hour. Four boats were then attached, and the same speed was attained, the engine working very smoothly. The experiment was deemed successful, and if it was in fact successful, it is difficult to see why the thing could not be done on a much larger scale on the Erie Canal.

Orders have been given for the construction of several engines of a small pattern to run on sets of rails to be laid alongside this canal, the rails being laid 18 in. apart. The engine drew eight laden boats at the rate of four miles an hour.—*Engineering News.*

The Longest Tangent in the World.—The new Argentine-Pacific Railroad from Buenos Ayres to the foot of the Andes has on it what is probably the longest tangent in the world. This is 340 kilometers (211 miles) without a curve. It is also a remarkable fact that in this distance there is not a single bridge and no opening larger than an ordinary culvert. The level nature of the country will be appreciated from the statement of the further fact that on the 340 kilometers there is no cut greater than one meter in depth and no fill of a height exceeding one meter. The country, in fact, seems to be almost an ideal one for railroad construction.

There are some drawbacks, however, one being that there is almost an entire absence of wood on the plain across which the western end of the road is located. This has led to the extensive use of metallic ties, which will be used on nearly the entire road. Work has already been begun on the mountain section of the road, which is to cross the Andes and unite with the Chilian line.

New System of Sewerage at Frankfort-on-the-Main.—In spite of the strong current and the great dilution, the previous system of disposing of the sewage at Frankfort-on-the-Main in the river Main has proved unsatisfactory, causing a great many complaints, and the corporation was therefore obliged to find some remedy. The course adopted by them was to cleanse the sewage before giving it access to the river, by purifying it. Experiments with this end in view have led to satisfactory results, gypsum being adopted as the chemical

cleaner. The sewage is first mechanically cleaned, as far as it is possible, and is then led into the clearing reservoir, which is about 300 ft. long and 100 ft. broad, with a depth of 18 ft. below high-water mark. The water passes through the reservoir at the extremely moderate rate of 5 millimeters in the second, which leaves ample time for the solid particles to settle. When the reservoir has to be cleaned, the water is first pumped out and the sediment removed by another special pump. The pumps and the machinery are so placed that the suction pipes need only be short ones.

The Redwood Forests of California.—In the redwood forests adjacent to San Francisco Bay and lying in the counties of San Mateo, Santa Cruz, Marin, Sonoma, Napa, and Alameda, most of the merchantable timber on the original growth has been removed, as the drain on these forests has been enormous. In the greater portion of these worked-over forests, where the stumps have not been removed to make way for fruit trees or vines, the great vitality of the redwood has asserted itself, and a dense growth of saplings has sprung from the mutilated butts, and is rapidly approaching a merchantable condition. The redwood forests on the range east of St. Helena, in Napa County, supplied all the ties used in the construction of the Napa Valley Railway, and the growth has been drawn upon for years past for posts and stakes for the vineyards and orchards that are taking the place of the forests. Railroads have not yet penetrated these forests, but when they do, as they are likely to do within a few years at least, they will acquire a great commercial value. As the redwood is the best and, indeed, the only timber available on a large scale, it is a great pity that the forests are being destroyed.

The Perekop Canal.—The Russian Government has begun the work of cutting the Perekop Canal, the original survey for which was made many years ago. This canal is to extend across the Isthmus of Perekop, connecting the Sea of Azoff with the Black Sea. It will be 111 versts (74 miles) long, and the present expectation is that it will be completed in 1891. As with most Russian works, the main object is military, to enable war steamers to pass from the Sea of Azoff to the dock yards and forts of Odessa without circumnavigating the Crimea or passing through the dangerous straits of Kertch ; but the canal also has commercial importance. The bulk of the trade from the Don River and a great deal of that from the upper Volga goes to Odessa, and the new canal will very much shorten the voyage for all the vessels engaged in this business, besides securing the further advantage that the grain barges employed on the Don will be enabled to carry their loads directly to Odessa without transshipment, the frequent storms on the Black Sea now making it necessary to transfer the loads of these barges to sea-going vessels at present. The canal presents no special engineering difficulties.

Railroads in Corsica.—Until February 1, 1888, the island of Corsica has been entirely destitute of railroads, but during nearly the whole of the present century the postal service, by diligence, has been as good in Corsica as in almost any part of the Continent, owing to the superb system of graded and macadamized roads.

But railroads are an essential adjunct of modern commerce ; without them the mines of iron, lead, copper, antimony, and zinc in the interior could not be profitably worked, and the export trade of the island could not compete with that of Italy and France.

Soon after the organization of the present French Republic, the Corsican deputies began to demand for their picturesque island a railroad system, but the high range of mountains which traverse the island, the spurs of which, in many places, run down to the coast and terminate in abrupt headlands, would necessarily make the work expensive, while the high cost of operating lines involving heavy gradients rendered the profit of the undertaking more than doubtful.

The National Government came to the rescue and surveyed the main line from Ajaccio to Bastia. Work was begun at Bastia seven years ago, and on the first of last month the road was opened for traffic as far as Corte—a distance of 45 miles. By reason of the high grades, numerous rock cuttings to be overcome, its cost has been $33,250 per mile. The tunnel, 10 miles south of Corte, is a difficult and costly task which cannot be finished in less than a year. The main line, from Bastia to Ajaccio, is a national work built by Government engineers at the expense of the State.

At present Corsica exports to the United States little except candied citron, and receives in return petroleum and leaf tobacco. If Corsican wines were as well known in our country as they deserve to be a large American trade in them might be developed. There are almost no manufacturers on the island, and it offers a promising market.

Egyptian Petroleum Fields.—Colonel Stewart has recently completed and submitted to the Egyptian Government a preliminary report on the result of his researches in the petroleum district, from which it would appear that he recommends experimental borings to the north of Jebel Tor, on the opposite side of the Gulf of Suez, where he claims to have discovered many indications that justify the conclusion that good results will eventually be obtained.

His proposals, it is understood, will be given due consideration as soon as a supplementary report, with details as to cost, etc., can be prepared and examined.

It would seem from this that, notwithstanding the many disappointments that threatened to end with failure to which the Egyptian Government has been subjected in its experiments at Jebel Zeyt and Gimsah, it is nevertheless disposed to venture additional sums in prosecuting the search for petroleum in the hope of finding it in sufficient quantities to compensate it for the enormous expenditures already incurred.

It was confidently hoped and maintained that oil in remunerative quantities was more than likely to be encountered at a depth of about 1,000 ft. ; but the limit has long since been reached, and passed by many hundred feet, and the long and much-wished-for expectations are yet to be realized. It seems clear that the Government, having lavishly expended—not to say wasted—extravagant sums in the development of what promised to prove a source of great revenue to its greatly depleted and needy exchequer, does not appear to be willing or feel justified in relinquishing its exertions and labors until all hope of success must be finally abandoned.

Of the presence of petroleum over a vast area there exists no longer any doubt, but whether its extraction will ever yield a proper remuneration or return is yet problematical. It is not improbable that the present generation will have to follow the example of those that preceded them thousands of years ago, who, from indelible traces left to posterity, were fully aware of the existence of petroleum, but appear to have abandoned its exploitation as an unprofitable task.—*Report of Consul Bissinger, at Beirut, to State Department.*

Baltimore & Ohio Employes' Relief Association.—The report of this Association for the year ending September 30, 1887, shows total receipts for the year of $367,350, and a balance of $205,907 on hand at its close. Payments of benefits during the year were :

	No.	Amount.
Deaths from accident	73	$80 000
Deaths from other causes	130	57,496
Disablements from injuries	3,974	53,521
Disablements from sickness	6,517	97,590
Surgical bills	2,259	13,835
Total	12,953	$302,442

The business of the Association has largely increased during the past year, as shown by the fact that the present active membership is 22,155, an increase over last year of 1,858. Since the inauguration of the Association (May 1, 1880) 70,029 persons have been admitted to membership, of which number 10,922 made application during the past fiscal year.

The examination to determine the physical condition of persons applying for membership has resulted in the rejection of 1,460 out of a total of 18,353, and of 149 of those who were examined for sight, hearing, and color sense.

The Savings Fund and Building Feature shows total deposits of $441,804. During the year 381 new deposit accounts were opened. The total amount received from depositors during the year was $221,893, an increase over the previous year of $12,103, making the aggregate of deposits since August 1, 1882, when the Savings Fund was inaugurated, $730,560 ; of which $288,756 have been withdrawn, and the sum of $453,787 has been loaned, at the rate of 6 per cent. interest, to those employés desirous of obtaining homes upon the lines of the Railroad Company, of which $122,109 have been repaid.

This amount was expended in building 259 new houses, buying 257 houses, improving 69 houses already owned, and releasing liens in 153 cases. The loan feature has become exceedingly popular, the applications to utilize this feature largely exceeding, during almost the entire year, the funds available for this purpose.

Railroads in Colombia.—A consular report submitted to the Department of State says that the railroad system of the interior of Colombia is as yet in its embryonic stage and slow in growth. The only road in actual service is the Bolivar, between Barranquilla and Salger. The railroads to be considered are the Bolivar, Cauca, Jirardot, the Antioquia, and the Dorado, the Bolivar being the first in importance and in its service and aid to foreign commerce as well as in its perfect management.

The mouth or delta of the Magdalena River is obstructed more or less at all seasons by a shifting bar formed by the sedi-

ments of the Magdalena and its tributaries. Vessels enter the river with from 18 to 20 ft. of water on the bar, but a few days later, when cleared for departure, there may be but 9 or 10 ft., and vessels have been lost on the bar when in tow of a powerful tugboat and piloted by one of the best experts on the coast. It was to obviate this peril to life and property that the Bolivar Railroad was constructed.

When the branch to Puerto Colombia is completed, steamships can lie alongside a pier in smooth water to discharge and receive freight.

The Bolivar is under American management; it is owned by private parties. The rolling stock now in service, of English manufacture, will be replaced as the necessity arises with American. The extension of the branch road to Puerto Colombia, on the northwest side of Salger Bay, makes the distance from the Barranquilla terminus to the pier 18 miles. The Salger terminus will probably be abandoned in the immediate future.

The Cauca Railroad, the construction of which was commenced in 1878 and which was to connect with Cali and the west bank of the Cauca River, has its present terminus at Cordova, 12 miles from Buenaventura. It is now Government property; has been surveyed to Cali, but the work has been suspended.

The Jirardot Railroad has been completed to Portillo, 12 miles. The line has been surveyed to Bogota, a distance of about 80 miles. It is a Government enterprise, and presents engineering difficulties of no ordinary character. The work is progressing slowly, but owing to the topographical features of the route 6 per cent. gradients will be necessary at several points on the line of survey; and it is considered doubtful whether the road when completed will ever pay its running expenses.

The Dorado Railroad is a portage road between the navigable waters of the lower and the upper Magdalena around a series of rapids and falls at Hondo, which forms a barrier impassable by steamboats.

The bridge across the river at Hondo will probably be built in the future, but as yet nothing has been done toward its construction. Some five years ago a Colombian railroad enterprise was inaugurated to construct a railroad from Puerto Wilches, on the eastern bank of the Magdalena River, to follow the valley of the Sogomosa River and reach Bueurmauga. The line was surveyed and a short section of track, less than a mile, was laid.

The Antioquia Railroad from Puerto Berrio to Medellin, 125 miles, has been completed to Pavis, 30 miles from Puerto Berrio. The first contract for this road was signed in February, 1874, modified May following, and in July, 1876, a new contract was made for the termination of the line at Barbosa, a distance of 100 miles from Puerto Berrio. This also is a road of heavy gradients.

Petroleum and Natural Gas in Japan.—From an article prepared for the *American Manufacturer*, by Jinzoo Adachi, we learn that petroleum and natural gas are found in Japan. They were known there at least ten centuries ago, but have never been used until recently. This has been partly from the abundance of vegetable oil and wood fuel which cover the whole of Japan, but more from the peculiar policy of a long reign of feudalism.

The oil-bearing rocks in Echigo consist of soft, greenish-gray shales and gray fine-grained sand rocks, sometimes with small quartz pebbles. In Echigo fibrous lignite is sometimes closely associated with black shining coal. The oil-bearing rocks appear generally to be in folds that have axes running nearly northeast and southwest, sometimes so sharply waving as to form perfectly closed folds with the dip reversed on one side.

The present mode of oil-well digging is very simple, and not many more men are needed than for boring with steam. The digging is all done by two men, one of whom digs in the morning from 9 o'clock until noon, and the other from noon until 3 o'clock. The one who is not digging works the large blowing machine or bellows that continually sends fresh air to the bottom of the well.

The oil is never pumped, but is hoisted out of the well by buckets. These buckets are attached to a rope, which runs over a wheel at the surface, and while one bucket is coming up the other is going down, the weight of the empty bucket thus helping the one man who does the hoisting. The average bucket contains five gallons.

The American method of well drilling has been tried twice, but has failed. The Japanese plan is to dig a well 3½ ft. square, resembling the vertical shafts of the mines of Pennsylvania.

A well 300 ft. deep would cost $300, and would be completed in three months.

In Echigo there are several yielding oil wells of small product, but the most interesting feature is a couple of gas wells some 10 ft. in diameter, near together, where the gas bubbles up in great quantity with violent commotion in water nearly level with the ground, and burns with dancing, flickering flames when lighted. At another spot within half a league some gas is utilized in a house for cooking, lighting, and even as a spectacle when burned in jets of various size and position; but all the flames are flickering ones. At the same place the gas is used to heat a small rude still for refining the oil of the neighboring regions.

In 1874 the total production of petroleum was 123,156 kwan, and in 1884, 1,139,624 kwan.

The number of productive wells in 1879 were 874; average daily yield, 4 gallons; average depth, 177 ft.; greatest depth, 780 ft.

The results of practical refining from the crude oil at Echigo show an average of about 60 per cent. of refined oil.

The International Exhibition at Berlin for the Prevention of Accidents.—The Prussian Government has permitted the gratuitous use of a large exhibition place in Berlin near the Thiergarten and the Lehrte railroad station, for the purpose of showing practically how accidents may be prevented. The exhibition is to take place from April to June, 1889. The invitation to participate in the exhibition is extended to all nations.

The articles to be exhibited are to consist of machinery, apparatus of all kinds now in use to guard against accidents, in tools, working pieces and working materials, in models; in plans, drawings, photographs and specifications; in copies of regulations, rules for factories, statutes and printed matter relating to accidents and to their prevention. All articles that relate generally to the protection of laborers will be admitted.

The exhibition will have, to some extent, the character of an industrial exhibition, with the difference only that objects which are solely for technical purposes are excluded.

Groups 1 to 12 contain detailed suggestions to enable manufacturers and masters to answer for themselves the question, how far their participation in the Exhibition may be conducive to valuable results.

The division into groups is as follows:

DEPARTMENT A.

Groups 1 *and* 2: Prevention of accidents near movable machine parts, generally; productive devices in transmission shafts, toothed wheels, beltings; disengaging gear, lubricating appliances, etc.

Group 3: Protective measures in the working of elevators, lifters, cranes, derricks and other raising apparatus and machines.

Group 4: Protective measures on motors.

Group 5: Protective measures in the operation of steam boilers and other apparatus under pressure.

Group 6: Preventive devices against, and safety devices in case of, fire in insured works and workshops.

Group 7: Providing for good illumination and prevention of accidents by means of lighting arrangements.

Group 8: Prevention of accidents caused by poisonous (caustic or corrosive substances) obnoxious gases, etc.

Group 9: Personal equipment of laborers.

Group 10: Provision for injured persons.

DEPARTMENT B.

Group 11: Steps for the protection and well-being of working people in the metal industry.

Group 12: Steps for the protection and well-being of working people in the wood industry.

Group 13: Steps for the protection and well-being of working people in the textile industry.

Group 14: Steps for protection in the paper, leather, and polygraphic industries.

Group 15: Protection in the industry of articles of food and consumption.

Group 16: Protection in the chemical-glass industries.

Group 17: Protection in the mining and quarry industries.

Group 18: Protection in building trades.

Groups 19 *and* 20: Protection in the trades of intercommunication.

Group 21: Protection in the farming and forestry industries.

DEPARTMENT C.

Group 22: Literature (Library of the Exhibition).

Special attention has been bestowed upon protective measures for movable machine parts, as official statistics compiled for the year 1886, at the Imperial Insurance Office, show that, irrespective of the prevalence of various occasions for accidents in the several trades, in the entire sphere in "insurance in case of accidents," such accidents as were caused by movable machine parts occupy, among the more severe cases, the first place in number. Not less than 100,000 cases of accidents were reported in the year 1886; 10 per cent. of the laborers injured under the insurance laws being entitled to an indemnification.

THE RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

PUBLISHED MONTHLY AT No. 45 BROADWAY, NEW YORK.

M. N. FORNEY, ... Editor and Proprietor.
FREDERICK HOBART. . . . . Associate Editor.

Entered at the Post Office at New York City as Second-Class Mail Matter.

SUBSCRIPTION RATES.

Subscription, per annum, Postage prepaid............... $3 00
Subscription, per annum, Foreign Countries........... 3 50
Single copies.. 25

Remittances should be made by Express Money-Order, Draft, P. O. Money-Order or Registered Letter.

MR. J. HOWARD BARNARD, 7 Montgomery Avenue, San Francisco, Cal., is the authorized Western Agent for the JOURNAL.
MR. FREDERIC ALGAR, Nos. 11 and 12 Clements Lane, Lombard Street, London, E. C., England, is the authorized European Agent for the JOURNAL.

NEW YORK, AUGUST, 1888.

THE Editor of THE RAILROAD AND ENGINEERING JOURNAL is now engaged in collecting material which he contemplates using hereafter in writing a history of the engineering of American railroads. Parties who have in their possession, or know of the existence of, any drawings or documents available for this purpose—such as drawings of old locomotives or cars, maps, profiles, etc., reports, or any other documents, written or printed—will confer a favor by informing us of the fact. Any books, documents, or drawings which may be intrusted to the Editor for this purpose will be treated with the utmost care while in his possession, and will be returned safely to the owners.

THE steamboat men on the Mississippi have always been opposed to the building of any bridge over the river below St. Louis, and when permission was finally secured for a crossing at Memphis they sought to make it as difficult as possible by demanding a clear opening of 1,000 ft. The Board of Engineer Officers to whom the question was referred was divided in opinion, and the Secretary of War has finally decided to approve the original plan, which was for a three-span bridge, the center span to be 730 ft. and the others each 600 ft. long. The bridge is to be 75 ft. above the river, so that no draw will be required.

The final plans have not yet been submitted, and the method of construction to be adopted for these very long spans is not known, if it has been decided on.

THE proposed bridge over the Hudson River at New York City was recently the subject of a hearing before the Board of Engineer Officers, to whom the plans have been referred by the Secretary of War. The project submitted was that prepared by Mr. Gustav Lindenthal, which was described in our columns some time ago, and which is for a bridge with a single span of 2,850 ft. and a height of 140 ft. above the water.

Not much interest was manifested in the hearing. Mr. Lindenthal submitted arguments in favor of his plan, but only one or two persons appeared in opposition, and their only objections were that 140 ft. was not sufficient height for the bridge. The Board will submit a report to the Secretary of War on the question.

THE Poughkeepsie Bridge is rapidly approaching completion, and will probably be ready for use in October, as far as the bridge structure itself is concerned. Its connections, however, are still in the air, as very little has been done yet toward the construction of the line running from the Western end, and nothing at all on the branch road, which is to connect its Eastern end with the New York & New England road. Until these are finished the completion of the bridge will be of very little practical use.

There are rumors current, which seem to have some foundation, that large if not controlling interests in the bridge company, and in the NewYork & New England Railroad, have been obtained by the Vanderbilt interest. To the New York Central & Hudson River Company, the bridge alone is, of course, of no use whatever, but that the chief owners of that road should have considered it best to control the new rail connection for New England business is not at all improbable. The New York & New England road has been in the market for some time, apparently, without any one desiring to purchase it. The New York Central has derived so large a portion of its support from New England business that its owners could afford to invest a considerable amount of money to prevent more active competition for that traffic.

That could be done, as suggested above, by controlling the New York & New England, as it is the only important line likely to cross the river at Poughkeepsie. This road has done some Western business, but so long as it was hampered by the ferry transfer at Fishkill, and by its very imperfect terminal facilities there, it could not be regarded as a formidable competitor. With the bridge connection completed, however, and trains running directly across the river, the conditions would be changed, and it might be so used as to inflict great injury upon the Central. It is true that the Western connection over the bridge will be with the Erie and not with the Central, but turning over a portion of this business to its rival would be of less importance to the last-named company as long as the rates and connections were under its control.

Should these reports be true, the business of the bridge is likely to be smaller than its projectors have estimated, and to consist chiefly of coal and similar freights, rather than of through Western traffic.

THE plan for constructing a bridge over the English Channel has just been completed. It has been worked out by the Creusot engineers and M. Hersent, ex-President of the Society of Civil Engineers. The progress of metallurgy makes the construction possible of an immense bridge 30 kilos. long, with a floor at a height of 50 meters above the sea at full tide, and supported by piers at a distance of 500 meters apart. The Forth Bridge, which is being constructed in Scotland, under which the largest vessels can pass, is an advance toward this more important structure. The Channel Bridge will support four railroad lines, be-

sides a road for carriages and a foot-path. Places of refuge, watch-houses, and alarm-bells will be placed on each pier, with a powerful light. The bridge will cost 800,000,000 francs, and it might be constructed in six years.

The English Parliament recently refused, by a large majority, to pass a bill permitting the building of a tunnel under the Channel, and it is hardly probable that it will favor this scheme. The reason for this opposition is the fear that it may be used by an invading army to enter the country ; but that seems a very poor one when we consider how easy a thing it would be to destroy or block up the tunnel or bridge.

THE production of pig-iron for the first half of 1888 shows much less falling off from the corresponding period of last year than had been expected from the general statements made with regard to the condition of the iron trade. The reduction is small in amount, and was chiefly in the anthracite furnaces, a number of which have gone out of blast, some on account of labor troubles and others from the high cost of coal, which has made it impossible to work at a profit in view of the present prices of iron. The production of iron by the furnaces using bituminous coal or coke show an increase, and the total amount—1,900,000 tons—was only 162,000 tons less than the very large output of the second half of last year. In charcoal iron also there was a small increase, but in quantity this class of pig-iron is not important, its amount being only 8 or 9 per cent. of the total production.

The condition of the blast furnaces on July 1, indicates that the production of the second half of the year will be less than for the second half of 1887, but it does not at present seem probable that the falling off for the whole year will be very large.

A NEW plan for rapid transit in New York is suggested by D. C. Linsley, an engineer, who is making arrangements to organize a company. His plan is for a masonry viaduct running through the blocks, crossing the streets at a considerable elevation, and the route he proposes is on the west side of the city, starting from the Battery and running for the most part west of all the present elevated lines to Spuyten Duyvil, from which point it is proposed to continue it as a surface line as far north as Tarrytown. Carrying the road through the blocks will, of course, require the purchase of a large quantity of real estate, but it is proposed to utilize this by building warehouses and shops in the arches of the viaduct.

The general plan of a masonry viaduct running between the streets is not a new one, having been often suggested, although the details have never been worked out so fully as in Mr. Linsley's plan. It is not apparent yet, however, that there is any considerable amount of capital behind this plan, and it is not probable that work will be begun very soon.

THE figures given by the *Railway Age* for the first half of 1888 include 3,320 miles of new railroad on which track has been laid this year. This is only about 400 miles less than the amount reported for the first half of 1887, when the total for the year reached nearly 13,000 miles. It is not to be expected, however, that the figures for 1888 will equal those of last year. A great part of the new mileage so far built has been in completion of that begun last year, and the number of new roads begun has been very much less ; moreover, there are very few long lines now in progress, the mileage being made up of a number of short roads built by many different companies. The great companies, such as the Chicago, Milwaukee & St. Paul, the Chicago & Northwestern, the Chicago, Burlington & Quincy, the Missouri Pacific, and the Atchison, Topeka & Santa Fé, are doing comparatively little this year. The Chicago, Rock Island & Pacific, which did not begin to extend until late, has still a number of lines in progress, while the St. Paul, Minneapolis & Manitoba and the Northern Pacific are still pushing the construction of branches in Dakota and Montana. The Union Pacific has also several new lines under way, and will probably begin several others before the close of the year. Upon the whole, however, the prospect for new lines is not as good as it was a year ago, and the desire to build has apparently been checked by the unfavorable experience with new branches which those companies, which were the most active before, have had this year.

A very large proportion of the new road built so far this year has been in the Southern States, where there is still abundance of room, and where there has been, for the last year or two, a much healthier condition of things than in the West, the new roads being mainly feeders pushed into new territory, and not parallel or competing lines. Next to the South the most active building has been in California, where nearly 400 miles are reported, chiefly branches of the Southern Pacific and of the Atchison systems. Southern California especially will soon be pretty well supplied with railroads.

The estimate of 10,000 miles for 1888, which was made early in the year, will have to be reduced somewhat, and the figures will probably fall considerably below that. Enough new road will be built, however, to insure a fair degree of activity in the trades which furnish materials, so that no great depression is to be looked for.

Taking the whole country together, under its present circumstances, the growth of the railroads should be somewhat slower than that of population. An addition of from 3 to 5 per cent. yearly to our railroad mileage would represent about the normal and healthy growth which would be best for the prosperity both of the country and the railroads themselves.

THE launching of the *Charleston* at San Francisco, on July 18, marks another important step in the reconstruction of the Navy. This vessel, which has been built by the Union Iron Works, is the second—the *Chicago* being the first—of the large cruisers ordered for the Navy to reach the water ; her displacement is one-fourth greater than that of the *Boston* and the *Atlanta*, and is only very slightly less than that of the *Chicago*, being 3,730 tons. The *Charleston*, moreover, is the first of the new ships constructed especially for high cruising speed, and the first whose plans were adopted under the present administration of the Navy Department. She is also the first ship to be fitted with the latest and best type of machinery, and it is expected that her engines will work up to 7,500 H.P., or more than twice the power of the *Atlanta*, although they occupy very little more space, and weigh only about 10 per cent. more than the engines of that ship.

The plans for the *Charleston* were not original, the vessel being in most respects a copy of the *Nanawa-Kan*, the famous cruiser built at Elswick, England, for the Japanese Navy, which was, when she entered into service, the fast-

est war-ship in the world, although her speed has since been exceeded by one or two. The plans of the *Nanawa-Kan* were purchased by the Navy Department from her builders, and used for the *Charleston*, with some slight alterations suggested by experience. The general dimensions of the vessel are 300 ft. long, 46 ft. beam, and 18½ ft. mean draft. She will be heavily armed, carrying a side battery of 6-in. guns and also two 10-in. pivot guns, with the usual secondary battery. She is what is known as an unarmored cruiser, the vital part of the vessel being partially protected by a curved steel deck, and the machinery is also further guarded by the arrangement of coal bunkers. She will be fitted with all the latest improvements in the way of electric lights, torpedo protection, ventilating apparatus, and so on.

SETTING aside a few torpedo boats which can only keep up their speed for a very short distance, it is now claimed that the German Navy possess the fastest armed cruiser in the world. This vessel, which was recently completed at Kiel, has a displacement of 2,000 tons, with engines of 5,400 indicated H.P. The *Greif*, as she is named, on the voyage from Kiel to Wilhelmshafen attained the extraordinary speed of 23 knots an hour. She has, as may be supposed, been built exclusively for speed, carrying a light armament, and having her space almost entirely taken up with boilers, engines, and coal bunkers. She is of the class of ship known as torpedo-boat hunters, and is the first of her kind in the German Navy, although the English have several. The *Greif* is undoubtedly the fastest naval cruiser in the world, considerably exceeding in speed the English 20-knot cruisers, and one or two which were added to the French Navy a short time ago. How long her cruising can be kept up is not stated.

THE bill which we have already mentioned as pending before the Massachusetts Legislature, authorizing the organization of a naval reserve as part of the State militia, has become a law. It provides for a naval battalion to consist at present of not more than four companies, and to have a full complement of officers. Officers and men alike are required to have sea experience, or to be engaged in seafaring pursuits. The complete operation of the law is dependent upon the co-operation of the United States Government, which is to be asked to furnish a vessel and guns for the training of the men; but it is expected that there will be no difficulty in securing this assistance.

THE Japanese have for several years past shown considerable activity in railroad building, and their lines so far constructed have been very successful. The latest road proposed in that country is on the Island of Kiu-Siu, the most southern of the four large islands composing the Empire. The route proposed is from a port on the Shimonoséki Strait on the north end of the island to Nagasaki in the southwest, traversing the whole island and having several branches, the total length to be constructed being about 275 miles. There are now no railroads on that island, the only open port being Nagasaki, and the interior is less visited by foreigners than any other part of the Empire. It is known, however, that the population is large, exceeding 5,000,000 persons, and that a large part of the country is very productive. Moreover, a portion of the road will pass over extensive coal fields, which are now worked at Miiki, where a considerable amount of coal of very good quality is mined.

If built as proposed, and there seems to be a strong probability that construction will soon be begun, the road will differ from all others in Japan, from the fact that it will be owned by a private company and not Government. Under the laws of that country, however, the management will be under strict Government regulation. A preliminary survey is now being made by a German engineer, but it is stated that several of those who are most interested in the construction of the line advocate the adoption of American methods, and there may be an opportunity to furnish American material.

THERE has been started in the Argentine Republic a project for a railroad line to connect that country with Bolivia and Peru, and eventually to form part of a grand International railroad running the whole length of the South American continent. The transcontinental line from Buenos Ayres is now completed, or nearly so, to Jujui, a distance of 993 miles. The last-named place is only about 100 miles from the Bolivian frontier, and from it to La Paz, the capital of Bolivia, a distance of 500 miles, a new line would have to be built. From La Paz to Santa Rosa there is a line in operation 220 miles long, and from Santa Rosa through Cuzco in Peru and Santa Rosa in Ecuador, to Hiradot in Colombia, a distance of 1,520 miles, some of it through very difficult country, a new line would have to be built. From Hiradot to Bogota in Venezuela, a railroad 140 miles long is under construction. The total length of this proposed line from Buenos Ayres to Bogota, it will be seen, will be about 3,425 miles, of which 1,350 miles are completed, leaving 2,075 miles to be built. After reaching the table-land of Bolivia the road would follow the heads or upper waters of the numerous tributaries of the Amazon on the western side of the Andes, and would not anywhere have to cross the mountains.

A second line which has been indicated follows the existing road from Buenos Ayres to Santa Rosa, 450 miles, reaches La Paz in Bolivia by way of Asuncion in Paraguay, and follows from La Paz the same route as the first.

The length would not differ from the other very much, but it is claimed that it is a better one both for construction and traffic. Two or three other alternative routes have been proposed and discussed, and there are advocates for a line running up the Andes from Quito northward, which, it is claimed, would serve to develop the richest mineral country in the world.

The advocates for the construction of this South American International Railroad point to the great extent of valuable country which would be developed, and also to the fact that all the countries on the line would be willing to extend material aid both by grants of land and by guaranteeing interests on sums invested in construction.

Whatever line may be adopted, connections could be made with the Cerro di Pasco and other rich mineral districts by branches, while nearly the whole of the country can be made to furnish products for export which would give traffic to the road, which would furnish the best outlet. Bolivia, for instance, is a country known to possess very great natural resources which have never been developed simply because, while it is comparatively near the Pacific coast, everything going to the country westward

has to be carried across the Andes, while to the east its only outlet has been through the Amazon and its tributaries, whose banks are for many miles occupied by hostile Indians, and in which there are serious obstructions to navigation. The Brazilian ownership and control of the lower Amazon has also been an obstacle to commerce in this direction, as the republics of the western coast have always been jealous and somewhat afraid of their powerful eastern neighbor.

Buenos Ayres is more than 10 times farther from La Paz than Valparaiso, yet the former is much the more accessible port of the two by land.

The project, as a whole, is a very extensive one, but it really does not present more difficulties than did the Pacific railroad question in this country 30 years ago. The obstacles to its execution are more of a political and financial nature than physical, for it does not appear that there is anything on the line which cannot be overcome by competent engineers. It is not improbable that in some form it may be realized before the close of the present century.

AT the recent convention of the Society of Civil Engineers, one of its members said that he thought that the committee of the Master Car-Builders' Association should be dismissed for advocating an increase in capacity of cars. No doubt the Car-Builders will do this when they learn the wishes of the civil engineers.

THE committee appointed by the Society of Civil Engineers on the Relation of Wheels to Rails, about two years ago, seem to have difficulty in reaching conclusions. At the convention in Milwaukee, according to the *American Engineer*, they reported that much work had been done on this, and statistics had been gathered and were now in shape for a report, but the conclusions were not yet quite ready.

PROBABLY the most important engineering work now under way in Great Britain is the Manchester Ship Canal, work upon which has just been begun after a long period of preliminary agitation and discussion. This canal will form a connection between the city of Manchester and deep water in the river Mersey, partly by the construction of an entirely new canal and partly by the widening and deepening of existing water courses. It is intended when completed, to give a depth of 26 ft. of water up to the basin and docks in Manchester, and the entrance lock is to be made so deep that it can be worked at all stages of the tide, so that the delay now occasioned in entering the docks at Liverpool will not affect vessels going into the canal. The completion of this water-way, and the opportunity which it will offer to large vessels to go directly to Manchester, will save a very large amount, it is expected, in the expense of handling traffic which is now sent to Liverpool by rail for shipment. In the case of heavier goods this saving will amount to a very appreciable percentage on their cost.

The canal will serve not only the city of Manchester itself, but a large part of the district of which it is the center, and which is probably the most densely populated and active manufacturing district in the world. The estimate of its projectors is that very moderate tolls will insure an excellent return upon its cost, while the benefits to business generally will be very great.

THE use of the locomotive for drawing canal boats has often been proposed, but has never, we believe, been carried into practice. Some experiments of this kind have recently been made in England, where the question of the improvement of canals and their more extensive use is now under discussion. Without having any detailed account of the results of these experiments the general statement is, that they have been very successful, and it is proposed to extend the use of the locomotive for that purpose.

A light engine would be sufficient to haul several boats where the canal is in such a condition that they can be run together, and the laying of a track to carry such a machine on the towpath of a canal should not be an expensive matter. A heavy locomotive would not be necessary, and, indeed, would be out of place, for such tows as a 40 or 50-ton engine could take would be entirely impracticable on any ordinary canal, and there could not be any grades to overcome. The plan seems to be meeting with much favor in England, and is worth considering here. It has already been sufficiently proved in coal mines and logging railroads and for other purposes, that a locomotive is much more economical than animal power, and the extension of this principle to a canal ought to be a matter easy of arrangement.

IN Westminster Abbey in London, recently, the memorial window which has been placed there in memory of Richard Trevethick was uncovered, thus commemorating, fifty-five years after his death, one of the greatest of early English engineers. While Trevethick originated and advocated many of the ideas upon which later progress in steam engineering depends, he was himself unsuccessful, and died in great poverty. He was the first man to design a practicable locomotive; he advocated the use of a high pressure of steam at a time when such an idea seemed to most engineers absolutely chimerical, and in many other directions he had what seems to us a most extraordinary foresight. He was in advance of his age, and it is well that he has been remembered by a later generation, which has adopted his ideas.

A WEST VIRGINIA inventor has devised a pilot for locomotives, which, he claims, is not only an excellent cow-catcher and snow-plow, but will also do away with the disastrous results of butting collisions. His pilot, he says, "will in case of a collision throw both trains from the track, spreading the track, and forcing the locomotives to rake each other from the road-bed, a checked gradual derailment far less destructive to life and property than by direct collision." In other words, when this arrangement is used, should two trains meet upon the same track, instead of telescoping with mutual destruction, they will glide gently and quietly to either side of the track with all the ease and grace of a young lady and a gentleman meeting on a narrow sidewalk.

There is no doubt that such an invention will be extremely useful, and that it will render the train-dispatcher's mistakes perfectly harmless. It is not entirely complete, however, and needs an additional device, which might be attached to the rear of the train, to enable the two trains to return to the track after their gentle collision, or, rather, harmless derailment, and thus avert any evil consequences from lingering too long in close proximity, which might be almost as dangerous for trains as for the parties on the

sidewalk. Probably our West Virginia friend will be equal to this, however, and it will be enough to simply call his attention to the incompleteness of his invention in its present condition.

ACCIDENTS FROM "WALKING OR BEING" ON RAILROAD TRACKS.

IN their last report the Railroad Commissioners of the State of New York give the number of persons who were killed in the State from "walking or being" on railroad tracks as 341, and 222 more were injured. As there are about ten times as many locomotives in the whole country as there are in the State of New York, we may make a rough-and-ready approximation of the whole number killed and injured by simply multiplying the above figures by ten, which would give us 3,410 killed and 2,220 injured, or a total of 5,632. As these figures represent an appalling amount of pain, sorrow, and of consequential destitution, some general inquiries were sent out some time ago, in connection with an investigation of a similar character, to learn, if possible, whether the class of accidents referred to could be lessened, and, if so, by what means.

To the question, "Can you suggest any way of lessening the number of accidents to employés from 'walking or being on the track?'" the following replies were received from experienced railroad officers. A number answered "No;" four said "by staying off the track;" others recommend the enforcement of trespass acts; three suggest the use of a steam bell-ringer on locomotives; two propose a foot walk alongside of tracks; one proposes overhead foot-bridges, and another "a proper enforcement of rules in regard to speed through yards: a stringent rule requiring a brakeman to be on the front car of every train that is being pushed, and he to be held accountable; more care in the selection of employés for yard service; the use of bulletins giving all employés, particularly track and maintenance of way men, full information as to movement of trains, and the display of signals from elevated points for all delayed or unscheduled trains."

The Railroad Commissioners of New York say: "The danger seems to be inevitable, and incident to the occupation."

The Commissioner of Railroads of Michigan says: "Laws might be enacted providing a penalty for going upon a railroad track, but in most parts of this State would be a very unpopular measure, and one which there is no probability of the Legislature enacting. In fact, where the penalty is death for neglecting to care for themselves, it is difficult to see how much more can be done unless the railroads are fenced in such a way as to make it impossible for people to get upon the track."

The Chief Engineer and Manager of the Canadian Government Railways, in a reply to the Committee, said: "Regarding your suggestion as to the efficiency of notices placed at frequent intervals, I may say that my own experience leads me to the conclusion that they are wholly ineffectual. I have not only tried notice boards, but at certain points, when the track was especially made use of as a highway, I have stationed constables to warn off trespassers, and even to turn them off if necessary. This caused very bad feelings, and was even regarded as an infringement of the liberty of the subject. If the public could only be brought to support any movement to prevent people from endangering their lives in this manner, it would not be difficult to find a remedy. But at present it is quite the reverse."

The Commissioners of Mississippi say: "The plan adopted by the Illinois Central Railroad of posting conspicuous warnings to persons to keep off track, stating that it is company property and intended only for its use, and trespassers are at their own risk, is the best I know for lessening the number of accidents to persons walking on track."

The Secretary of Internal Affairs of Pennsylvania says: "The great danger of such a habit or practice should, we think, be evident to every one."

These replies show the futility of the means which have been adopted. Of course, fencing railroads, the abolition of grade crossings, or placing gates and watchmen at all such crossings are preventative measures, but their universal adoption on all roads is impracticable, and will be so for many years to come. Then there is no direct responsibility for such accidents. If persons will expose themselves to such danger railroad companies are not blamed for the results, if they use proper precautions to prevent them. It would be fallacious to say that it is as dangerous to walk or be on a railroad track as it is to go into a bloody battle, but the number of killed and wounded annually in this country as a consequnce of exposure to this danger is as great or greater than the loss of life and the casualties of many important battles.

The question occurs, then, why, if the danger of walking or being on the railroad track is so great, do people expose themselves to it? The answer is obvious, they do not realize it. Probably very few experienced railroad officers appreciate the imminence of the danger of being on the track, although they have for years been engaged in railroad employment. A few months ago the writer saw two ladies walking on the track of a railroad near a large city where there are frequent trains, with an umbrella which —to speak in a Hibernian way—was hoisted low down, so that it was impossible to see and difficult to hear an approaching train, and they seemed quite oblivious of their danger. The papers tell almost daily of persons who, in getting out of danger from an approaching train on one track, step into the jaws of death on another, on which there is a train moving in the opposite direction. The fact is, the Secretary of Internal Affairs of the State of Pennsylvania to the contrary notwithstanding, the danger of the habit or practice of being on the track is not evident to every one.

If it were possible to make persons realize fully the danger they incur the moment they are on the track of a railroad and not inside of the cars, much would be done to diminish the class of accidents referred to. It is usually the feeling of security which constitutes their danger. If they were alarmed and alert they would be likely to see and escape the risks to which they are otherwise exposed.

The thing to do then, if possible, is to make the danger apparent in any way that will be effectual. A notice that

A RAILROAD TRACK IS AS DANGEROUS AS A BATTLE-FIELD

might attract attention, but it is not strictly true. If conspicuous notices, somewhat as follows, were posted on railroad tracks where they are most needed, they would be

sure to alarm some persons who expose themselves to danger because they fancy they are safe on a railroad track.

IT IS DANGEROUS TO WALK OR BE ON A RAILROAD TRACK! MORE THAN 5,000 PERSONS ARE KILLED OR SERIOUSLY INJURED EVERY YEAR IN THIS COUNTRY AS A CONSEQUENCE OF EXPOSING THEMSELVES TO SUCH DANGER.

There is no hope that a notice of this or any other kind will prevent the practice of walking on railroad tracks, but it would have the effect of making many persons more cautious who now are very careless, and thus save some lives.

Another analogous class of accident on railroads is that of employés being struck by water-cranes, poles, walls, switch-stands, etc. Of these the Railroad Commissioners of the State of New York say that "the Board deems that this class of accidents could be greatly diminished by having such structures removed further from the track; and it deems that the distance should not be less than 5 ft. from the rails, and that all structures should be removed from between the tracks unless there is a distance between such tracks of at least 11 ft. A car projects about 2 ft. 7 in. beyond the rail. This proposed distance of 5 ft. from the rail, therefore, would leave but 2 ft. and 5 in. between the outside of car and the structure—none too great a distance."

No argument is needed on this point, but human life is cheap, and moving switch-stands and other structures cost money.

NEW PUBLICATIONS.

THE COAL TRADE: BY FREDERICK E. SAWARD, EDITOR OF THE "COAL TRADE JOURNAL." New York; published by the Author.

This is the fifteenth yearly number of a valuable work, which is, as its title-page says: "A compendium of information relative to coal production, prices, and transportation, at home and abroad."

It is a general review of the coal trade of the country, both anthracite and bituminous, the figures being taken from official sources wherever possible, and in all cases from the best available authorities, and carefully arranged and tabulated. The long experience of the Author and his intimate acquaintance with the trade have enabled him to work to advantage, and to make a book which is not only the best, but really the only convenient book of reference for this important trade.

How great its importance is will be seen when it is stated that the total output of coal in the United States last year was about 120,000,000 tons, being over one-fourth of the total estimated coal production of the world—a proportion which is yearly increasing, as the development of this industry is proceeding more rapidly here than in any other country.

ABOUT BOOKS AND PERIODICALS.

A CAREFULLY prepared paper, by Professor Arthur T. Hadley, of Yale College, on the "Rise and Growth of the Railway as a Corporation," will appear shortly in SCRIBNER'S MAGAZINE. The writer is one of the few who has made a study of railroad corporations, and is one of the leading authorities on this subject in the country. This paper will be doubly interesting, for just at present there is a great deal of interest in corporations with relation to the public and the law.

The third article of the Railroad Series, entitled "American Locomotives and Cars," appears in SCRIBNER'S MAGAZINE for August. It is by M. N. Forney.

The AMERICAN METEOROLOGICAL JOURNAL offers a prize of $200 for the best original essay on Tornadoes, or description of a Tornado; one of $50 for the second best, and $50 divided among those worthy of special mention. A circular giving full details can be obtained by application to Professor Harrington, Astronomical Observatory, Ann Arbor.

NEW YORK RAILROAD MEN for July contains an article on the Westinghouse Air Brake which is worthy of a careful reading; also the last of the three articles on Railroad Books in the Library, by James Eagan.

BOOKS RECEIVED.

REPORT OF HENRY A. HANCOX, C.E., ON THE WATER SUPPLIES IN THE VICINITY OF MILFORD, N. H. Published by the Selectmen of the Town.

OCCASIONAL PAPERS OF THE INSTITUTION OF CIVIL ENGINEERS. London, England; published by the Institution. The present issue includes Discharges from Circular and Egg-form Sewers, by William Thomas Olive; Compressed Oil-gas and its Applications, by Arthur Ayres; Indian Woods Suitable for Engineering Purposes, by Kuahya Lall Pai Bahadur; Arched Ribs and Voussoir Arches, by Harold Medway Martin; Creosoting Timber in New Zealand, by William Sharp; Economy Trials of a Non-condensing Steam-Engine, Simple, Compound, and Triple (with discussion), by Peter William Williams.

Another installment of these valuable papers includes Paved Carriage Ways in Sydney, New South Wales, by Adrian Charles Mountain; Machinery for the New Steel Works at Terni, by Hugh Savage; Manganese Steel (two papers and discussion), by Robert Abbott Hadfield; Abstract of Papers in Foreign Transactions and Periodicals.

FROM THE RECORD OF TESTS OF STEEL MANUFACTURED BY CARNEGIE, PHIPPS & CO., LIMITED, PITTSBURGH, PA. This little pamphlet contains tabulated records of a large number of tests of Bessemer and open-hearth steel made at the works of the company named, and showing the uniform quality of the product.

CROSBY STEAM GAGE & VALVE COMPANY: CATALOGUE, 1888. Boston; issued by the Company.

WELDING, TEMPERING, BRAZING, FORGING, AND SHAPING OF METALS BY ELECTRICITY: DESCRIPTION OF PROCESSES. Boston, Mass.; issued by the Thomson Electric Welding Company.

DWIGHT'S TRAVELERS' HANDY BOOK. Springfield, Mass.; published by the Dwight Print. This little book contains a sort of compendium of information for travelers; it comprises four parts: What to Do in Case of Accident; Rights and Liabilities of Passengers on Railroads; Railroad Signal Code Adopted by Leading U. S. Railroads, and other miscellaneous Useful Information.

Hypercycloidal Gear.

To the Editor of the Railroad and Engineering Journal:

Among the readers of the article upon this subject, published in your April number, were some who took sufficient interest in the matter to turn to your advertising columns, and finding my address there, honestly wrote to me for more information in regard to the "Hypercycloid."

It is true that the article mentioned was rather a description of results attained than details of how to attain them. These latter, however, as the law requires, are fully explained in my patents, which are not concealed.

It is interesting to see the effect, the lighting up of the countenance of a good mechanic, when he begins to realize that, as the ellipse may be of any proportion from a straight line to a circle, so the family of the Cycloidæ cover the same range—*i.e.*, from a straight line to a circle by another road; and as, in all the various proportions of the ellipse, the conjugate diameters and tangents are all subject to the same law, so in the Cycloidæ the tangents and secants have each a single value throughout the family. To quote from the patent referred to, "the tangent =

$$\sqrt{\text{sine}^2 + \frac{\left(\text{natural secant} - \text{cosine} \times \text{sine} + \frac{\text{sum } x}{6.2832}\right)^2}{\text{sine}}},$$

and

$$\text{secant} = \text{cosine} + \frac{\text{natural secant} - \text{cosine} \times \text{sine} + \frac{\text{sum } x}{6.2832}}{\text{sine}}$$

Also the versed sines are all natural, but the conversed sines vary from a minus quantity to infinity."

The common cycloid, epicycloid, and hypocycloid are all members, either simple or under especial limitations, of the family of the Cycloidæ. The involute is no relation of theirs, but one of the Conchoidæ, a cousin, so to speak, of the Conchoid of Nicomedes. In passing it may be remarked that the Conchoidæ, like the Cycloidæ, are a family whose range is from the straight line to a circle, according as x or y may = 0.

It is perhaps a weakness of human nature that causes a man who has done a certain thing in a particular way to try to do another thing in the same way, and if the result is tolerably fair, to look for no better way; and by continuing in the same practice to come at last to think that there is no other way. Now if any man likes to draw all of his water from one well he is at liberty to do so; but when he tells others that there is no other well in the world, men think that his world is very small. So mathematicians, having found that if the teeth of bevel gear taper in all of their proportions to a single *point*, they may run with relatively equal speeds in all of their corresponding parts, and make theoretically perfect work; so far they say true; but when they say that such gear are practically perfect, and further, that no other kind can be either theoretically or practically correct, they teach falsehood.

It is a quality of good generalship that enables the commander to use the means at hand; if his men have no powder he will close and use the bayonet. But mechanics let themselves become such slaves of habit that a man transferred from one turning engine to another will make that fact his excuse for inferior work.

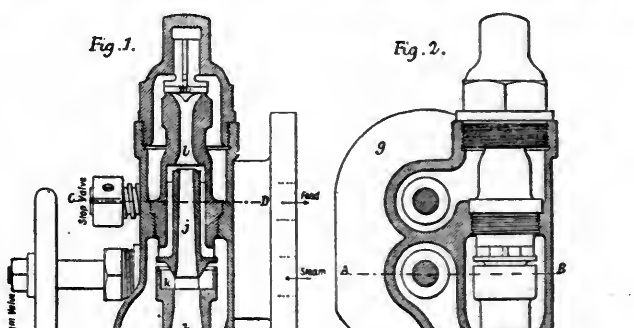
When a mechanic learns that good work is good work; that the intrinsic value of a result is not to be gauged by *who* or *what* contributed thereto, he is educated beyond the average, and may attain to that degree of intelligence that he may understand that the various curves mentioned above are not to be represented by portions of circles any more than a circle, or themselves for that matter, are to be represented by a series of straight lines. The man who would run a polygonal journal in a polygonal bearing as "an approximation," in place of a circular journal in a circular bearing, would show fully as much sense as the man who makes gear teeth with portions of circles, or with cycloids or involutes, or any other poor approximation.

When the mechanical world, finding that such results are attainable without difficulty, demands gear that run as close, smooth, noiseless, and perfect in all their action as a fine-fitted circular journal in a circular bearing, then mechanics will make such gear, and those gear teeth will be Hypercycloidal.

ALOHA VIVARTTAS.

Gresham & Craven's Combination Automatic Injector.

THE accompanying engravings, figs. 1, 2, 3, and 4, which, with the description, are taken from *Engineering*, illustrate the most recent form of what is called the combination automatic injector, manufactured by Gresham & Craven, of Manchester, England, and figs. 5 and 6 show the method which has been adopted by Mr. Francis R. F.

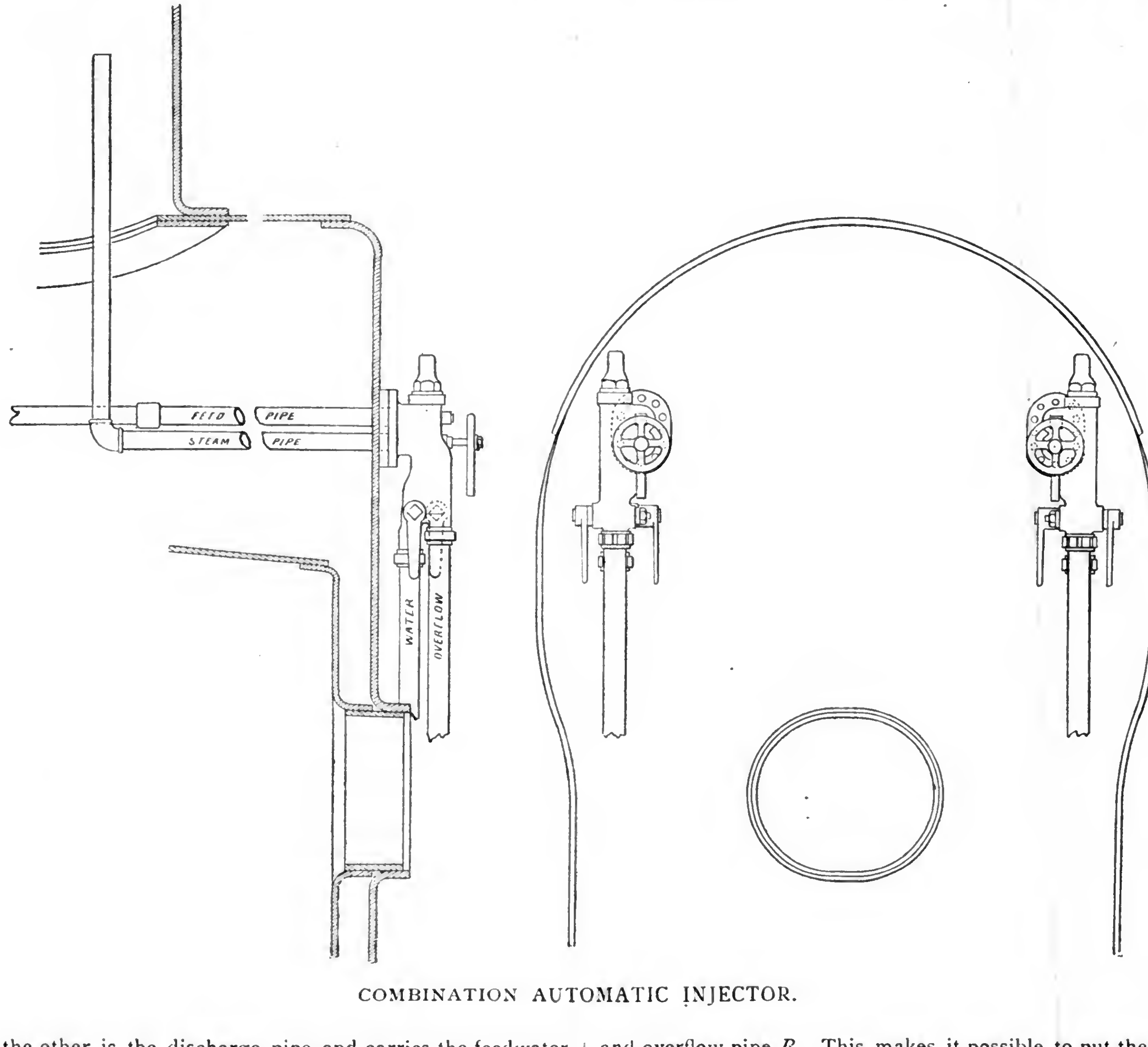


COMBINATION AUTOMATIC INJECTOR.

Brown, Mechanical Superintendent of the Canadian Pacific Railway, in applying it on that road. It will be seen from the illustrations that openings have only to be made at one place in the boiler, and the instrument is complete in it-

self, being provided with, as its name implies, all the necessary valves, viz., a steam valve, a back-pressure valve, a stop valve, a water valve, and a warning cock; it nevertheless barely exceeds in size and weight the common type of injector. With injectors previously introduced it has been found necessary, when they were to be used as lifting injectors, to fit them with a needle-shaped spindle for the purpose of adjusting the steam when lifting the water, and they have not, therefore, been commonly adopted on locomotives. With the new injector this spindle has been dispensed with, and the instrument is fitted at a level above that of the water in the tender to the back of the fire-box, through which holes are drilled for the insertion of two tubes of 1⅛ in. internal diameter, both carried inside the boiler. One of these leads to the dome, and through it is taken the steam supply to the injector, while the footplate. To work the injector the fireman simply opens the valve *N* full, when the steam blows through the lower or fixed part of the combining cone *h*, creating a vacuum in the waste pipe by induction and passing out through the overflow. When the water lifted by this vacuum meets the steam, condensation takes place, and the upper or moving part of the combining cone *j* then falls on to its seat and becomes substantially part of the fixed cone *h*, being held firmly in position by the vacuum created by the inductive action of the combined jet of steam and water in passing the opening at *k*. This jet finally passes up the throat *l*, raises the back-pressure valve *m*, and passes into the boiler.

Figs. 5 and 6 show the method of attaching the injectors to the back end of the fire-box. It will be seen that there are no external pipes excepting the supply pipe *A*, fig. 5,



COMBINATION AUTOMATIC INJECTOR.

the other is the discharge pipe and carries the feedwater over the top of the fire-box, finally delivering it, as is usual, near the center of the boiler. From this it will be seen that only two external pipes are required, the water pipe from the tender and the overflow leading beneath the footplate.

Coming to details, figs. 1 and 2 are respectively side and front sectional elevations of the instrument, while fig. 3 is a cross-section through the steam valve on the line *A B*, and fig. 4 is a similar view through the stop valve on the line *C D*. The injector is attached to the boiler by the flange *g*. The water branch *e* is connected in the usual way to the tender, by 1½ in. pipe, while the overflow branch *f* is connected with a pipe of the same size leading below and overflow pipe *B*. This makes it possible to put these pipes entirely out of sight, and also gets rid of the danger of knocking off the check-valves in case of accident, which, it will be remembered, occurred in one case in Pittsburgh on the Pennsylvania Railroad some years ago, by which a whole car full of passengers were horribly scalded. Other accidents of a similar character have occurred on other roads, so that the danger is one which ought to be guarded against. There will also be considerable saving in copper pipe and labor thereon, and very little danger from freezing.

Mr. Brown is the first person who has applied injectors in this way to American engines. His example is worthy of imitation in this country.

THE PRINCIPLES OF RAILROAD LOCATION.

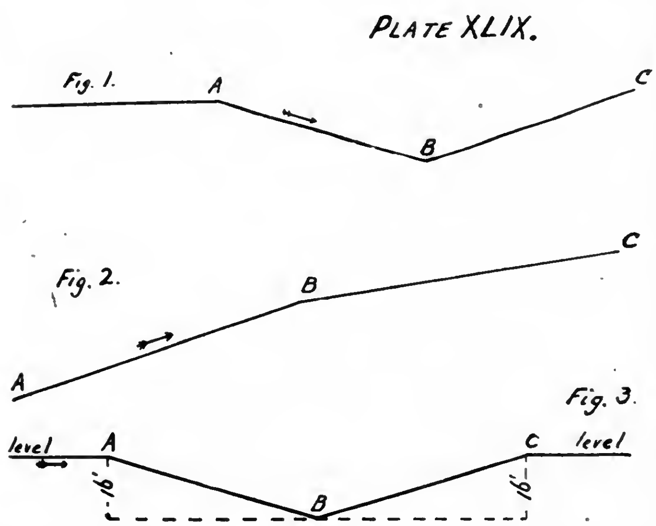
BY PROFESSOR C. D. JAMESON.

(*Continued from page* 301.)

CHAPTER XXVII.

REDUCING THE VIRTUAL GRADE BY MEANS OF MOMENTUM.

IN establishing any system of grades upon a section of railroad to be built, the engineer must always bear in mind the fact that, when the different grades are so situated in regard to each other that a train passing over them can acquire a greater velocity than its normal speed, without developing any extra power in the locomotive, this surplus velocity can be used and will be used in the shape of momentum to help the train up the next grade, and that therefore the grade will be reduced, in regard to the power exerted by the locomotive, by just the number of vertical feet through which the momentum alone would lift the train. All the resistances to the movement of a train, with the exception of that due to the force of gravity on the inclined plane of the grade, may be left out of the question



entirely, as they are overcome by the power exerted by the locomotive.

All these resistances, such as internal friction, rolling friction, etc., due to any speed, are overcome by the locomotive when the train is running on a level, and if the locomotive continues to exert the same power they will be exactly overcome on a grade, and the only additional resistance is that due to the force of gravity alone or the amount of force necessary to lift the train vertically the total number of vertical feet surmounted by the grade.

To present the idea in a clearer manner: Suppose two grades come together in the manner shown in fig. 1, Plate XLIX. Let the train be running in the direction of the arrow. Suppose the train is running at a speed of 30 miles per hour when it strikes the down grade *A B*. If the locomotive continues to exert the same power that it did on the level track preceding *A B*, then in running down *A B* the speed of the train will increase in proportion to the number of vertical feet fall from *A* to *B*, and when the train reaches *B* it will have acquired a certain surplus velocity over and above its normal speed, and this surplus velocity is stored up in the train in the shape of power, which may be used to assist the train up the grade *B C*. Or in common parlance, the grades *A B* and *B C* are relatively so situated that it is possible to get a run at them and thus virtually reduce their height.

Suppose the two grades were situated as in Plate XLIX, fig. 2. In that case it would be impossible to get any run at the grade *B C* without increasing the amount of power exerted by the locomotive on a level, and the result would be either one of two things: the amount of power exerted by the locomotive must be increased or the speed of the train must be decreased.

To return to the question of storing up power by allowing the speed to increase in running down grade: The amount of power stored up at the foot of the grade will exactly equal the amount which the train would have if it had been dropped through the same vertical distance, and its speed or velocity at the foot of the grade will be the same as that which would be acquired by a body falling the total height of the grade. Starting with the normal rate of speed at which the train would run on a level with a locomotive exerting the same power, this stored up power will carry the train up the following grade exactly the same number of vertical feet. In Plate XLIX, fig. 3, suppose a train running in the direction of the arrow has a speed of 30 miles per hour when it reaches *A* and the vertical fall from *A* to *B* is 16 ft. Then, if the locomotive continued to exert the same power, the train when it reached *B* would have enough surplus energy and momentum to carry it up the grade *B C* exactly 16 vertical feet, and at this point, or 16 ft. above *B*, it would have a speed of 30 miles per hour, the same as it had at *A*.

If the train descends any grade with the locomotive exerting the same power continually—that is, the strain on the draw-bars or couplers remaining constant—the speed of the train will be gradually increased until the bottom of the grade is reached. The amount of this increase in the speed will depend directly upon the vertical distance the train drops, as has been shown. The vertical distance through which a body must fall to acquire a given velocity is expressed by the following formula of elementary mechanics:

$$h = \frac{v^2}{2\,g} = \frac{v^2}{64.32}.$$

Here, h = total height in feet.

v = velocity in feet per second

$g = 32.16$ = constant acceleration of velocity due to gravity.

This equation gives the velocity in feet per second. To change this into miles per hour $= V$, we have:

$$v = \frac{5280}{60 \times 60}\,V = 1.466\,V,$$

$$h = \frac{\left(\frac{5280}{60 \times 60}\right)^2 V^2}{64.32} = \frac{2.15\,V^2}{64.32},$$

$$v = \frac{\sqrt{h\,64.32}}{1.466}.$$

By this last formula we are enabled to calculate at once what the speed of any train would be at the bottom of any grade; and therefore know exactly how much surplus power, over and above the normal speed, is stored up in the train and available for use in surmounting the next

grade or running on a level with a diminished amount of power exerted by the locomotive.

There is a limit beyond which momentum grades cannot be used. This limit arises from the fact that there is a limit to the speed at which it is safe to run a train. When, in running down any grade, this point of safe speed is reached, any increase above it is prevented, first by shutting off the steam in the cylinders, and thus reducing the power exerted by the locomotive to nothing, and next, if the friction and resistance to motion is not sufficient to counterbalance the constant acceleration due to the incline, this resistance is increased by the application of the brakes until such a point is reached that the resistance due to the brakes (the friction between the brakeshoe and the rim of the wheel) plus the normal resistance to motion, is exactly equal to the amount of acceleration due to the incline. Under these conditions, the train will continue to move at exactly the same rate of speed over the remainder of the grade. As will be readily understood, the effect of these undulating grades is much greater upon freight trains than upon express trains, because the allowable maximum of speed is much greater in the express than in the freight, so that the constant acceleration of velocity on a down grade can be taken advantage of to a much greater extent than in a freight train, and also from the fact that, the normal rate of speed being much higher in the express than in the freight, any absolute differences in the rate of speed bear a much smaller proportion to the normal rate.

Thus, an express train running at the rate of 50 miles an hour encounters an up grade of 50 ft. rise. At 50 miles per hour the train has velocity enough to lift it 83.61 vertical feet; consequently, at the top of the grade it still has velocity sufficient to lift it 33.61 ft., which, by the above formula, we find equals a speed of a little over 30 miles per hour, while a freight train moving even at a velocity of 39 miles per hour would be at a standstill at the top of the grade, or, at least, only moving at a rate of 0.87 miles per hour. Now, 39 miles per hour is much greater than the allowable maximum speed of freight trains, which should never exceed 30 miles per hour. In establishing grades so that they may be conducive to the greatest economy in regard to taking advantage of accelerated speed, they should, when possible, never have so great a vertical fall as to require the use of brakes, nor so great a rise as to reduce the speed of freight trains below 10 miles per hour, as at this speed any slight variations in the circumstances under which the train is run will at once reduce this rate to zero and stall the train.

In considering the effect of grades upon the speed of trains as to increase or decrease, we have, as stated in the beginning, omitted entirely from the calculation all effect due to the resistance to motion of the train resulting from the many elements of friction always present.

All this resistance we have supposed to be overcome by the power exerted by the locomotive, and if the locomotive continued to exert this power constantly no allowance for this friction need be made; but, when running down grade the acceleration due to the grade soon does away with the necessity of any power being exerted by the locomotive. This is particularly the case with freight trains, where, as has been said, the increase in speed due to any given fall in grade bears a much larger proportion to the normal rate than in the case of an express train. The first thing, therefore, that is done on these grades in running down is to shut off all steam from the cylinders and thus do away with all tractive power. Under these circumstances, part of the force of gravity is used up in overcoming the normal resistance to motion of the train. We have considered this resistance to motion at 9 lbs. per ton. This is the resistance of the train behind the locomotive; in the present case, we have also to consider the resistance to motion in the locomotive itself considered as a car. The resistance to motion in a locomotive has been found to be from 15 to 20 lbs. per ton, depending upon the class of locomotive used. Taking this in connection with the 9 lbs. per ton due to the train, we can call the total resistance to motion in a train, including the locomotive, 10 lbs. per ton. Now, 10 lbs. per ton resistance in a train equals a grade rising 0.5 ft. per 100 ft., or a grade of 0.5 per cent. This grade is called the GRADE OF REPOSE—that is, the grade having such an inclination, that if a train is started down it at a given rate of speed it will continue running at that same rate, no faster, no slower, the whole length of the grade. The inclination of the grade of repose will vary with the initial velocity of the train, and the resistance it offers to motion. Now, it is to be noted that this grade of repose is not the grade upon which a train at a standstill, if left to itself, will start, but much less than that grade is. The resistance which must be allowed in starting a train from a state of rest is very much more than that encountered in keeping it in motion after it has once started. In running a train down a grade without steam the amount of velocity which it would acquire in descending a given vertical distance would not be as much as when running with just sufficient steam to keep up the normal rate of speed on a level; and, in order to find exactly what the velocity would be at any particular point, we use, not the actual vertical distance through which the train has passed, but this vertical distance less the amount of vertical fall the train would have passed through in running the same distance down the grade of repose.

Thus: A train running down a 1 per cent. grade one mile long, with all steam shut off, would not at the end of the mile have acquired the velocity due to a vertical fall of 52.8 ft. But the velocity due to a vertical fall of 52.8 — 26.4 = 26.4 ft.; 26.4 ft. being the vertical height in a grade of 0.5 per cent. one mile long or the rate of grade we have taken as the "grade of repose." In calculating the effect of grades upon the running of trains, the engineer must never fail to take into consideration this question of the grade of repose.

There is also another question which must be considered in the establishment of grades at stations or other points where there will be a stop. The conditions are as follows: When a train is started from a state of rest, the velocity at which it moves commences at nothing, and gradually increases until, within a certain defined distance, it must be the normal speed at which the train is run. To run a train at any uniform speed, there is required a certain expenditure of power by the locomotive, and to increase this rate of speed requires a corresponding increase in the power exerted, and this increase has the same effect upon the movement of the train that an up-grade of a certain rate and length would have. Suppose it is required to start a passenger train and so increase the speed that at a distance of 2,000 ft. from the starting-point it shall have a speed of 30 miles per hour. The extra amount of power which would have to be exerted would be the same that would be required to surmount a grade, the vertical rise of which in the 2,000 ft. would be the same as the distance through

which the train would have to drop to acquire the given velocity of 30 miles per hour; and, according to the formula given, would be 30.1 ft., or a little more than a grade of 1.5 per cent. This would be the grade representing the extra amount of power due to the acceleration in the velocity of the train. To find the grade which shall represent the total amount of power required, we must add to this 1.5 per cent. grade the grade of repose, 0.5 per cent., making a total grade of 2 per cent. for 2,000 ft., which represents the amount of power required to start a passenger train, and in 2,000 ft. have it acquire a speed of 30 miles per hour; or, when the actual grade at a station is level, the virtual grade under the above conditions would be 2 per cent. In order, therefore, to obtain the virtual grade at the station, or the grade representing the relative amount of power expended, we must add this 2 per cent. grade to the actual grade. From this will be seen the great evil of so establishing the grade line that a stopping-place comes upon a comparatively steep grade or of introducing a steep grade upon a long uniform grade that works the locomotive to nearly its maximum power. A long uniform grade for surmounting any considerable height is for many reasons theoretically to be preferred; still, on account of the general configuration of the earth's surface, such long uniform grades are objectionable from a constructive standpoint, and, in relation to the operating expenses, necessitate more development; and the introduction of pieces of grade of a less rate is found very advantageous. They give the locomotive, as it were, an opportunity of taking a long breath, and, owing to the ever-increasing tendency to load the locomotive up to its maximum limit, these breaks in the grade, even at the cost of an increase in length and curvature, are often not only admissible, but desirable.

CHAPTER XXVIII.

VERTICAL CURVES.

In order to be able to take full advantage of momentum in surmounting grades, even when the grades are relatively established in a manner that makes this possible, the changes from one rate of grade to another should be made by means of vertical curves and not by the grades meeting at an angle.

In Plate L, fig. 1, let *A B* and *B C* represent two grades where the rate of grade changes directly from the one to the other. This would be very objectionable at any rate of speed at which the train might be run over it, but particularly so when the train is to be allowed to gain in velocity in running down *A B* in order to surmount *B C*. In order to obviate these objections, the angle *A B C* should be changed into the vertical curve *a b c d e f. . . . q*. The manner of establishing these vertical curves is explained later. The objections to the grades meeting, as shown in *A B C*, are as follows: The train running down *A B*, with the engine exerting a uniform amount of power, has its speed constantly and uniformly accelerated by the force of gravity. When the engine passes *B*, this same force of gravity acts against the power exerted by the locomotive and tends to decrease the speed, and as soon as each car passes *B* the same effect is produced. The consequence is that in any train, but more particularly in the cars of a long freight train, with a low nominal rate of speed, as soon as the engine passes *B* the speed begins to slacken in it and also in each car as soon as it has passed this point. Part of the train which is still coming down *A B* will therefore crowd on the front of the train at the point *B*, and the tendency will be to lift some of the cars off the track.

When about all the cars, however, have passed the point *B* they will be crowded together and the speed of the center ones will be very much reduced. At this point, the pressure from behind being removed, the engine will begin to take out the slack in the couplings between the cars. The speed of the engine will be increased as the resistance of the train will be less, and the consequence will be that the train will lengthen out quickly and cause an excessive strain to come suddenly upon the couplings, which is often more than they can bear, and the train breaks apart.

There are two methods by means of which these objections may be overcome to some extent when vertical curves have not been used in connecting grades of a different rate, or when they are too short:

1. By the application of the brakes to the rear car in running down the grade *A B*, in order that this car may act as a drag upon the train and prevent the crowding of the cars at the point *B*. This obviates the crowding of the cars, and the danger of derailment, to a certain extent, but it also counterbalances the advantages which might be gained in the shape of increased speed with which to surmount the grade *B C*, as this extra power is used up in overcoming the resistance occasioned by the application of the brake. Another evil attending this is the increased wear and tear in the rolling-stock, rails, etc., due to the application of the brakes.

2. By having the engine pull out—that is, increase its speed—as soon as it has passed *B*, so as to keep the cars running at practically the same speed up the grade *B C* that it did in coming down *A B*, thus preventing the crowding at *B* or the breaking apart of the train. The evil of this method is that the power exerted by the locomotive must be increased and also that when the last cars of the train have passed *B* there is the possibility of a sudden jerk on the couplers of sufficient strength to cause the breaking apart of the train. Much of this danger, due to the sudden taking up of the slack between the cars, may be avoided by the introduction of improved forms of couplers that do away to a great extent with this slack. With the present generally-used form of coupler on freight trains, the amount of slack is about 4 in. for each car, more or less, depending upon the amount of force that has been used to compress the springs; so that in a freight train of 60 cars it amounts to 20 ft., and the locomotive has attained considerable speed before the last car feels the effect at all.

The result of this, however, is done away with by the adoption of the Janney, or any of the many similar forms of automatic couplers. As yet neither the automatic coupler nor continuous freight-car brake are in general use, but everything tends to show that it is only a matter of a very short time before at least all through freights will be equipped with them.

One great objection that has been urged for many years against any kind of freight-car couplers that allowed very little play or slack has been that it would necessitate the reducing of the weight of the freight trains that could be hauled by the same engine, owing to the fact that much more power is needed to start a train than to keep it in motion after it is once started, and in a train with the link coupler the cars could all be backed together and started one after the other, taking advantage of the slack.

The jerk on the caboose is something tremendous in such a case, and often the link or pin fails in strength.

But by means of elaborate experiments at Burlington, Ia., conducted at the same time and in connection with the famous Brake Tests, it was fully demonstrated that not only could as heavy a train, but even a heavier one, be started with close couplers than with loose ones. With the close couplers the only slack to be taken up is that due to the compression of the springs, and although this in actual distance is very small, still the reaction taken in connection with it makes the train easier to start, and does away almost entirely with the sudden jerk on the last cars. But even with all these modern improvements there still exist many and serious objections to the meeting of two grades at an angle, particularly when the grades are in the relative position of *A B C*. This is much more objectionable, in this case, than when the grades are in the position *D E F*, as shown in Plate L, fig. 2. Here a train running in either direction has a strain upon all the draw-bars and there is no chance of the cars crowding.

Many of these objections or evils may, however, be done away with by the introduction of vertical curves—that is, by so rounding off the angle at which the grades meet that in the *length of the train* there is no change of grade sufficient to cause any practical change in the strain upon the draw-bars. But this change, if any, should be made so gradually that the effect will not be felt either in the train or in the locomotive.

By experience it has been found that when the change in the rate of grade is not greater than 0.05 ft. per station of 100 ft. all the more serious evils which have been mentioned are done away with.

This amount of allowable change of grade depends upon the speed and length of the trains and, of course, varies as the circumstances vary. But as no change can be made in the track to correspond with the different trains, etc., some definite standard must be adopted which will apply to the average train and speed, and will also not materially increase the cost of construction, and a change per station of not more than 0.05 ft. fulfills the requirements. This is somewhat less, and makes the curve somewhat longer than the amount that is generally used; but it is none too small, especially before the general adoption of the automatic close coupler.

The method of staking out the vertical curve is as follows, the references being to Plate L, fig 1: Let *A B C* represent two grades meeting at *B*, each being a 0.4 per cent. grade. The total difference in rates is therefore $0.4 + 0.4 = 0.8$.

With an allowable change of rate of 0.05 per cent., the total length of the vertical curve would be $0.8 \div 0.05 =$ 16 stations, or 8 stations each side of *B*.

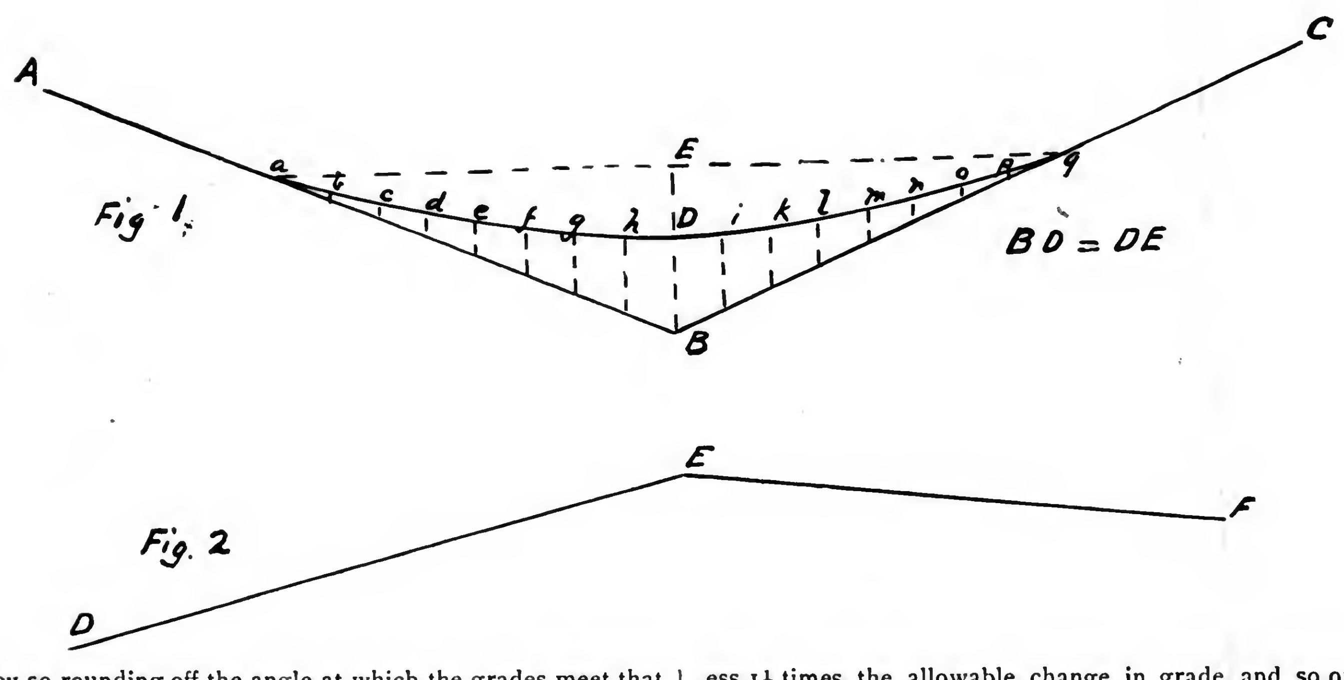
Thus we have the stations at which the vertical curve begins and ends, the elevations of these stations commencing with station *a* for example, the elevation of which we will take as 100.00; then the elevation of station *d* would be $100 - (0.4 - \frac{.05}{2}) = 100 - 0.375 = 99.625$, the elevation of the first station, minus the rate of grade, less one-half the allowable change in grade, and the elevation of station *e* would be $99.625 - (0.4 - 0.075) = 99.625 - 0.325 = 99.30$, or the elevation of *d*, minus the rate of grade, less $1\frac{1}{2}$ times the allowable change in grade, and so on. The rate of grade for each succeeding station being less than the preceding one by the allowable amount of change in grade until the point *D* is reached, when from *D* to *C* the rate of grade increases per station to within one station of *C*, when the increase is only one-half as much in this last station in order to change from a curve to a tangent. The elevation of *C* will be the same as before the vertical curve was introduced.

In order to check the work and also to calculate at once the greatest change that will be made in grade line by the introduction of vertical curves, the following formula will give at once the distance *D B*:

$$D B = \frac{A B + B C}{2} \times \frac{0.4 + 0.4}{4},$$

$$D B = \frac{(A B + B C) \times (0.8)}{8},$$

PLATE L.



$$A\,B + B\,C = \frac{0.8}{r},$$

$$D\,B = \frac{0.8^2}{8\,r} = \frac{0.64}{0.4} = 1.6.$$

Or let L equal $A\,B = B\,C =$ total length of curve.

$\Delta = 0.4 + 0.4 =$ algebraic difference between the two rates of grade calling up and down grades in the same direction respectively plus and minus, and $r = 0.05 =$ allowable change of grade per station. Then we have

$$D\,B = \frac{\Delta^2}{8\,r}.$$

This vertical curve will be a parabola from the fact that the stations are measured parallel to the grade and not horizontally. Thus, in Plate L, fig. 1, let $a\ b$ represent a station. The length of this station, 100 ft., is measured on the line $a\ b$, and the rate of grade or the distance $A\ c$ is the sine of the angle $A\ B\ C$, and not the tangent, as it would be if the stations were measured horizontally on the line $C\,B$. If $A\ C$ was the tangent to the allowable angle of change in the grade per station, and was equal for each station, the vertical curve would be circular. From the fact that the curve $a\ b\ c\ d$, *etc.*, is parabolic the distance $B\ D$ is always one-half $D\ E$.

(TO BE CONTINUED.)

TWIN LOCOMOTIVES.

FROM *Engineering* it is learned that "Messrs. Neilson & Co., Hydepark Locomotive Works, Glasgow, have completed a pair of twin locomotive engines and tender for the Indian State Railways (northwestern section). They are the first of the kind which Messrs. Neilson have constructed, and constitute part of an order of 20 engines and 10 tenders which the firm lately received from the Indian Government. The engines have outside cylinders with three pairs of coupled wheels placed between the cylinders and the fire-box. This allows the rigid wheel base to be the shortest possible. Between each two engines is placed a six-wheel double-ended tender, containing the fuel and water required by the two engines. Each engine is fitted with a powerful steam brake, which acts upon all the wheels, while the tender is furnished with a hand brake, which can be put in operation from either end. The leading dimensions of these engines and tenders are as follows: Diameter of cylinder, 19 in.; length of stroke, 26 in.; diameter of wheels, 4 ft. 2 in.; diameter of tender wheels, 3 ft. 7 in.; wheel base of each engine, 9 ft. 6 in.; wheel base of each tender, 9 ft. 6 in.; total wheel base of two engines and tender, 57 ft. 9 in.; total length over buffers, 80 ft.; contents of tender, 3,000 gallons of water and 8 tons of coal; weight of each engine loaded, 43 tons 11 cwt.; weight of each tender loaded, 40 tons 18 cwt.; total weight of combination, consisting of two engines and tender in working order, 128 tons. The engines are beautifully finished. They are to be employed in working the traffic on the heavy inclines on the Scinde-Pishin Railway, through the Bolan Pass."

As this is a somewhat new departure in locomotive practice, and one which seems to be very promising of good results where very powerful engines are required for working steep grades, engravings of a plan for twin locomotives described in an American patent granted to M. N. Forney, in 1882, may be of interest. Figs. 1 and 2 are copied from the patent referred to. Fig. 1 is a skeleton drawing of a pair of engines with the driving-wheels between the fire-box and smoke-box. $A\,A$ are two trucks located under the foot-boards of the engines. They are arranged to support the overhanging weight of the fire-boxes and the two ends of the tender T. The overhanging weight of the smoke-boxes is carried on pony trucks $B\,B$. With this arrangement the truck under the foot-board serves to guide the engine which is running with the fire-box ahead, and a pony truck guides the other engine while it is running with the smoke-box ahead.

FIG. 1

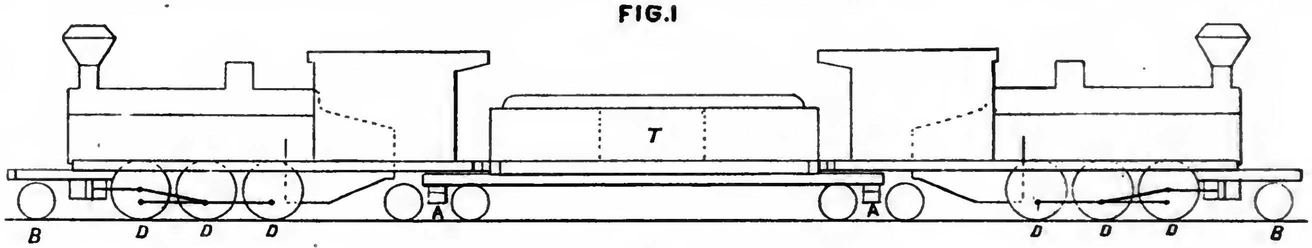
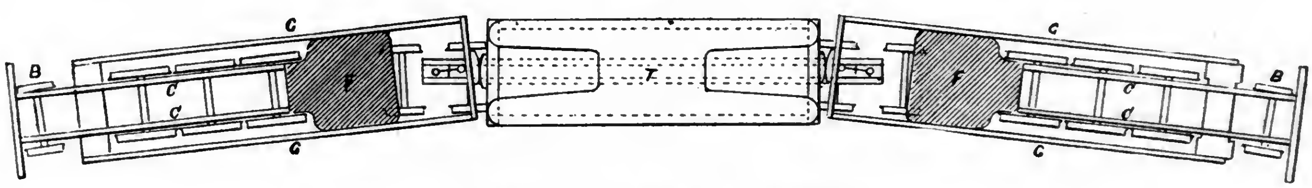


FIG. 2.



PROPOSED TWIN LOCOMOTIVE.

Fig. 2 represents a plan of the engine on a curved track. $F\,F$ are the fire-boxes, which it will be seen are widened out beyond the outside of the wheels. The main frames $C\,C$ are located in the usual way, with inside bearings, and abut against what is usually the front of the fire-box. Supplementary frames $G\,G$ are then placed outside of the fire-box, wheels, and cylinders, and are fastened to the fire-box and cylinders. Heavy transverse beams—not shown in the engraving—are bolted to the top of the main frames and extend outward, and the ends of the beams are fastened to the supplementary frames. The tractive power of the engine is thus transmitted from the main frames by these beams to the supplementary frames, which are coupled to the tender. This permits of the use of a fire-box as wide as may be desired, which is not limited in depth, as it would be if placed above the frames or wheels of an engine. It also allows the bearings of the driving-boxes to be made of any length, as the main frames may be located in any position. Usually the frames of locomotives are placed as far apart as possible in order to give the greatest practicable width for the fire-box. With the plan described there is no object in doing this, as the width of the fire-box is not influenced by the distance between the main frames, and therefore they can be located centrally over the driving-boxes, whose bearings may be lengthened to double the usual dimensions.

In the patent referred to, the application of the same general principles of construction, to what may be called unitary locomotives, is described.

NOTES ON STEAM HAMMERS.

By C. Chomienne, Engineer.

(Translated from the French, under special arrangement with the Author, by Frederick Hobart.)

(*Continued from page* 307.)

CHAPTER IX.

DISTRIBUTION OF STEAM.

For small hammers from 500 to 2,000 kilogrammes it is best to use the ordinary slide valves, as shown in fig. 25. This is the most simple and cheapest system ; the pressure which must be exercised at the end of the lever to work the valve is represented by the formula

$$p = P \times \frac{l}{L} \times K.$$

P here represents the total pressure exercised on the valve ; $\frac{l}{L}$ is the ratio of the levers or the distance traveled, and K is the coefficient of the friction of the valve on the face = 0.20.

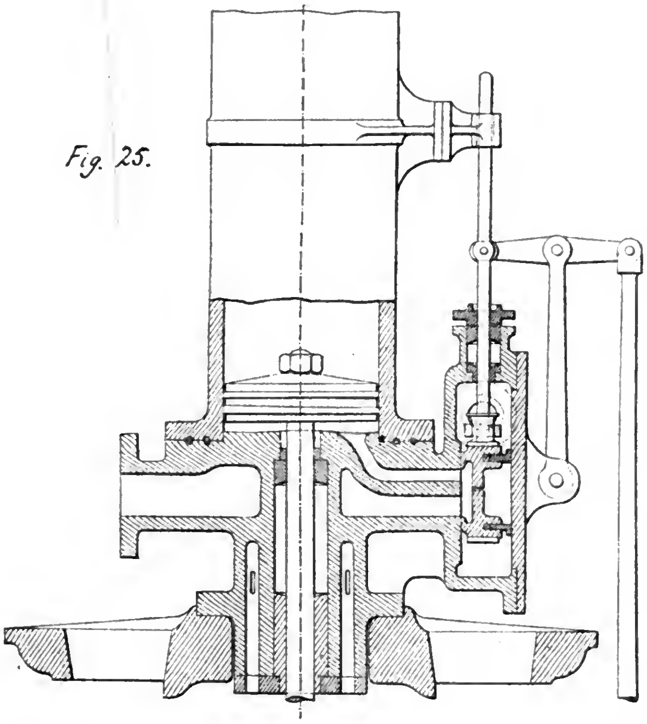


Fig. 25.

In any case, the pressure or work p should not exceed 12 to 15 kilogrammes.

For hammers over 2,000 kilos., two systems have been used : 1. Balanced valves with a double seat, as shown in fig. 26.

2. A circular or piston valve, as shown in fig. 27.

This last system has the advantage of being much more simple than the slide valve, and also permits the use of a heavier blow, the exhaust of the steam being much quicker than with the slide valve. It is also less subject to wear and derangement, and the leakage of steam is reduced to a minimum. The Works de l'Horme use this system for all hammers up to 50 tons.

In the case of distribution by slide valves, the lift should be equal to ⅛ of the diameter, and the valves should have only a very small contact with their seats in order to secure the nearest possible equilibrium and to diminish the work necessary to move them. The contact in small valves should never exceed 8 millimeters, and for the largest 3 or 4 millimeters as a maximum. Fig. 33 represents the exhaust valve of the 80-ton hammer of the Steel Works of the Marine.

If we adopt the ratio of the levers $l : L :: 1 : 15$, and a pressure of steam of 5 kilometers, we have

$$p = S \times 5 \times \tfrac{1}{15}.$$

From this we have $p = 26$ kilos. to work the exhau t valve and $p = 18$ kilos. to work the steam valve. Thes

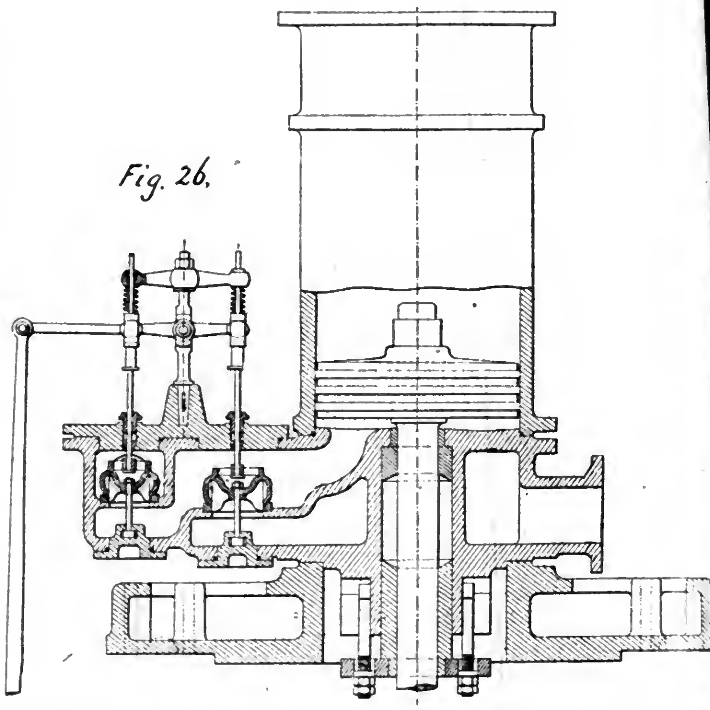


Fig. 26.

two figures represent the theoretic effort necessary to work these valves ; but it is really much less, as a light shock is sufficient to produce the opening of the valves, and from that moment the work to be done is only that necessary to overcome the friction of the joints of the levers, of the stuffing-boxes, and the valve rods, and finally that of the valves themselves and their guides.

The ratio of the levers should be so arranged that the hammerman will not have to execute a movement greater

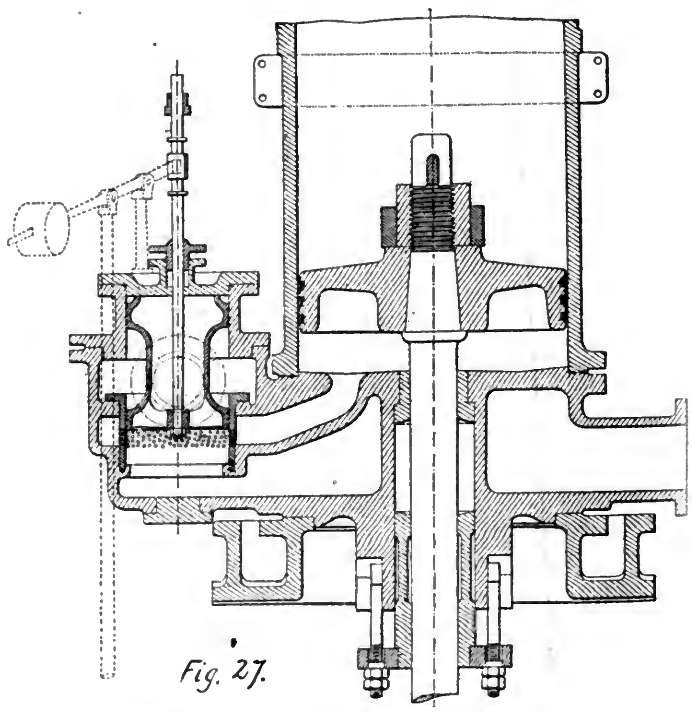


Fig. 27.

than 0.700 meter. In case of necessity two levers can be used, joined together by a stiff rod or handle and worked by two hammermen. In this way the work is divided in two parts, and the length of the movement can be diminished.

With a circular balanced valve or piston the work to be

done on the lever or hammer is only that required to overcome the friction of the joints of the levers, that of the stuffing-boxes, and finally of the segments of the piston in the cylinder. The only inconvenience arises from the lift of the valve, which is always much greater than that of the slide valve.

In general, in all the hammers used for forging parts of machinery or for stamping out large pieces, the distribution of steam is not automatic, but is made by hand, all that the steam can act instantaneously on the piston and escape quickly into the air. We should then adopt as large openings as possible, whether we use slide valves or piston valves.

The diameters of the steam and exhaust pipes should have the same section as the corresponding ports, and the relation between the two sections should be not less than 1 : 1.5; that is to say, the exhaust valve should have a section at least equal to 1½ times that of the steam valve,

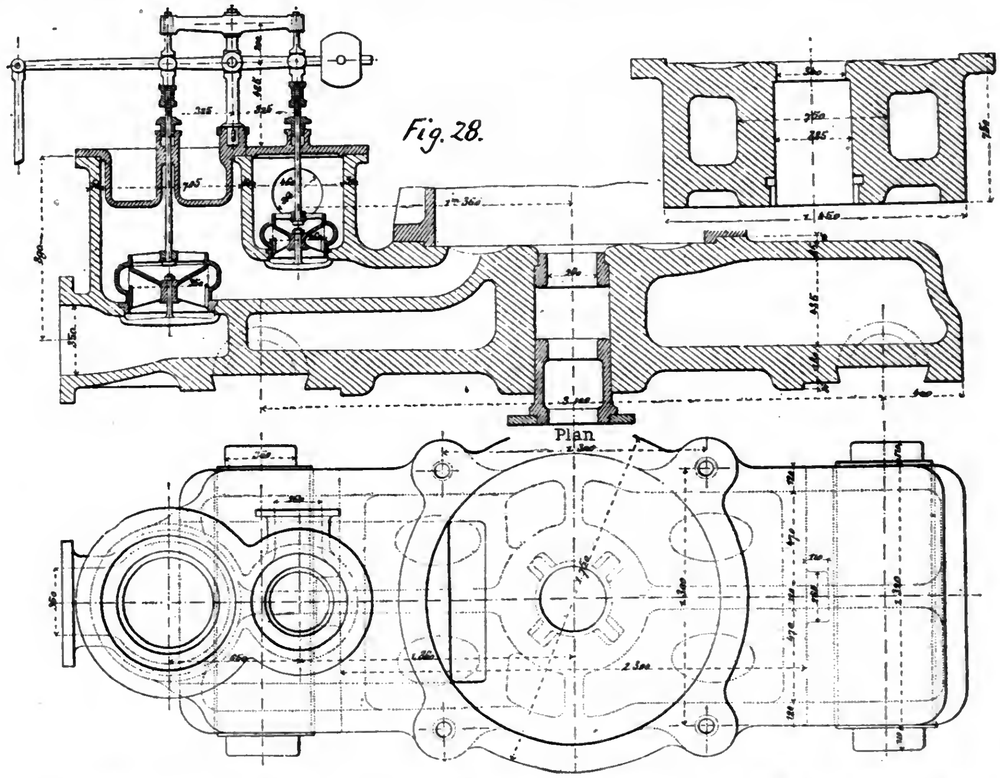


Fig. 28.

Fig. 29

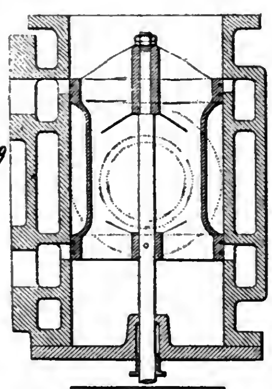


Fig. 30

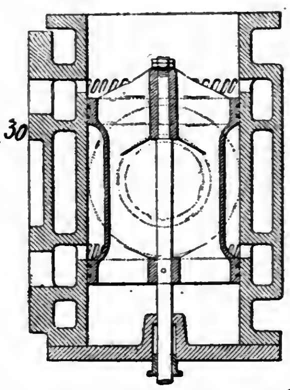
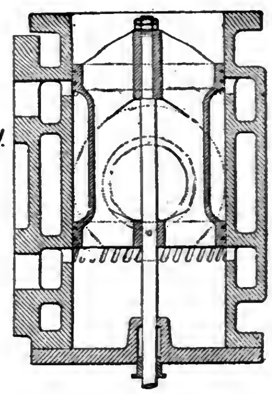


Fig. 31.



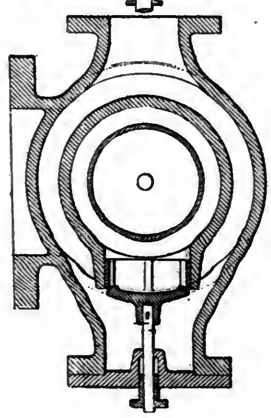
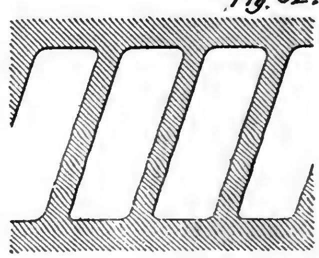


Fig. 32.



the inconveniences which could result from such an arrangement having been shown in practice.

In order that the hammer may be quickly and easily worked, the hammerman should have to make on the lever only a very slight pull and a short movement, while the steam and exhaust valves should have so large a section in order to diminish the counter-pressure, and to make the escape of steam into the air as easy as possible. The diagram accompanying—fig. 43—has been obtained by assuming: 1. An average steam pressure of 4 kilos.

2. A speed of admission of steam into the cylinder of 52 meters per second.

3. A speed of exhaust of steam into the atmosphere of 35 meters per second.

For higher pressures these dimensions may be reduced, and for lower pressures they should be increased.

In fig. 43 the ordinates represent the diameters which should be given the valves in millimeters; the abscissæ represent the power in tons of the different hammers; the heavy line corresponds with the exhaust valves and the fine lines with the steam valves. The minimum course of the hammer being 1 meter, the time which it occupies in descending is given by the formula:

$$t = \sqrt{\frac{2\,h}{g}} = \sqrt{\frac{2 \times 1.00}{9.81}} = \sqrt{0.20} = 0.''45.$$

As this fall is not in a vacuum, it is probable that the resistance of steam to the exhaust, the friction of the piston and of the piston-rod, etc., will increase the time to one-half a second.

On the other hand, the time of the lift of the hammer, which includes the action of the hand on the machinery and the volume of steam which will reach the cylinder in a second under the piston will be

$$S \times V = 0.0962 \times 52.000 = 5.000 \text{ cub. met.}$$

Consequently, the time required to fill the cylinder will be:

$$t' = \frac{13.665}{5.000} = 2.''73.$$

If we add the time of the descent to that of the lift we have:

$$T = t + t' = 1.''04 + 2.''73 = 3.''77.$$

This shows that the maximum number of blows which can be struck by this hammer per minute will be:

$$\frac{60}{3.77} = 16 \text{ blows.}$$

In the case of circular valves the diameter should be determined as for slide valves. The steam, after having acted upon the piston, will have to escape into the air by

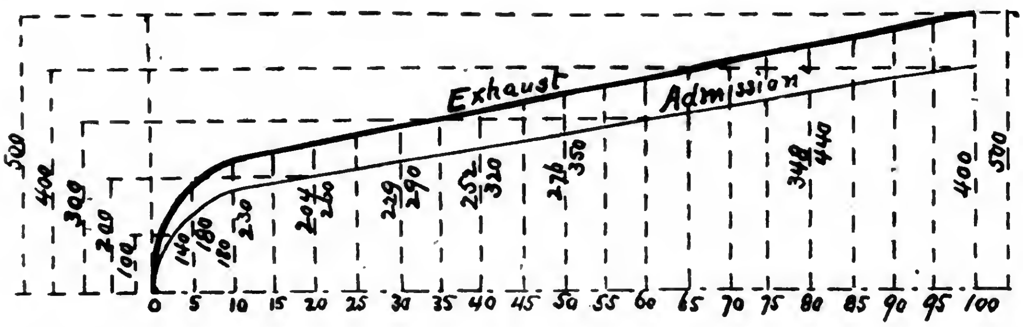


Fig. 43.

also that of the steam, cannot be less, and it follows that with a maximum course of 1 meter the blows given can only follow each other at the rate of 60 per minute.

If, again, we take the 80-ton hammer of the Steel Works passing through the same openings by which it was admitted, and the total section of these openings should therefore be equal to the section of the exhaust valve of a hammer of the same size.

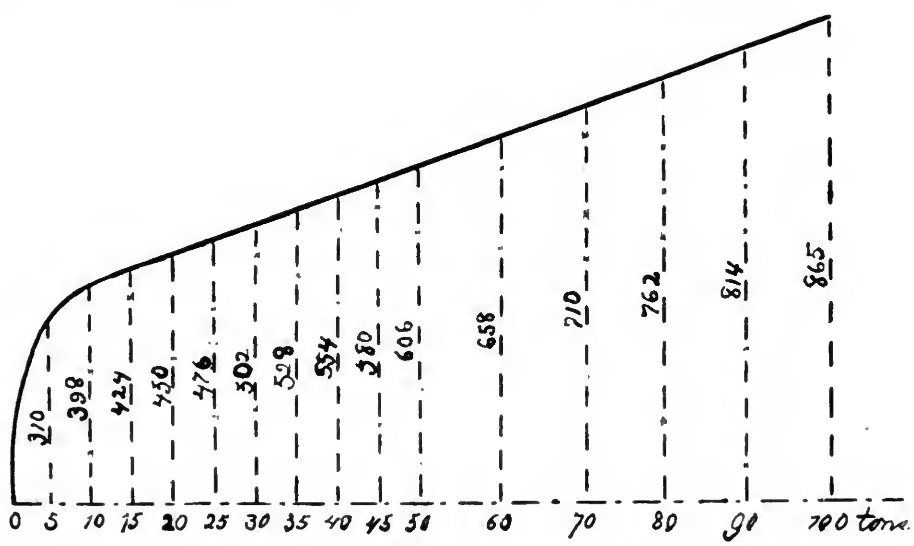


Fig. 44

of the Marine, whose fall is 5 meters, the time which the hammer takes in descending is:

$$t = \sqrt{\frac{2\,h}{g}} = \sqrt{\frac{2 \times 5.00}{9.81}} = 1.''04.$$

The volume of steam corresponding to this cylinder is:

$$\frac{D^2 - d^2}{1.273} \times h = \frac{1.900^2 - 0.360^2}{1.273} \times 5.000 = 13.665 \text{ cub. met.}$$

Here D is the diameter of the cylinder and d is that of the piston rod.

In assuming a speed of admission of steam of 52 meters per second and a steam valve of 0.350 meter in diameter,

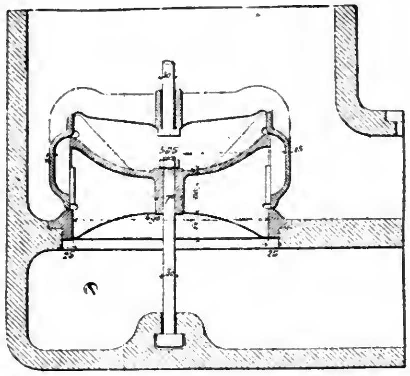
Fig. 34 represents the design of a circular valve for a 50-ton hammer of Marrel Brothers.

Fig. 44 shows graphically the diameter of the circular valves of hammers whose power varies from 1 to 100 tons. It will be seen that above 50 tons the dimension and travel of the valves are so great, that it will be very useful to have them worked by a separate motor, or small auxiliary engine, in such a way as to reduce to a minimum the effort to be put forth by the hammerman.

In fig. 44 the ordinates represent the diameter to be given to the valves in millimeters; the abscissæ represent the power in tons of the different hammers.

The following formula may be used to find the diameter of a circular valve, the size of the exhaust valve of a hammer of the same power being known. Let D be the diam-

eter of the exhaust valve of the corresponding hammer; S the area of this valve; D' the diameter of the circular valve; L the circumference of this valve, and h the width of opening of the valve, which ought to be



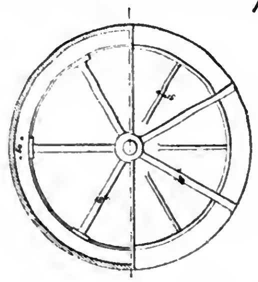
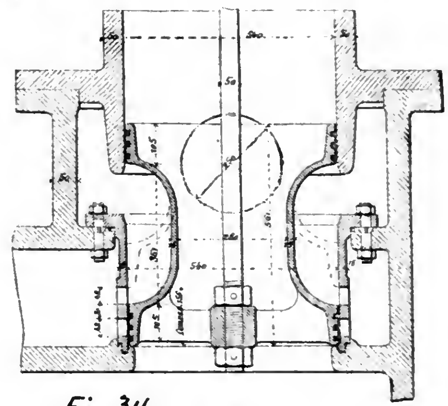


Fig. 33.



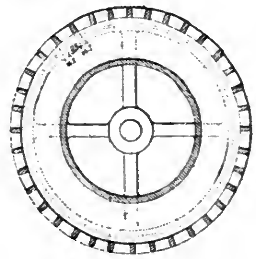


Fig. 34.

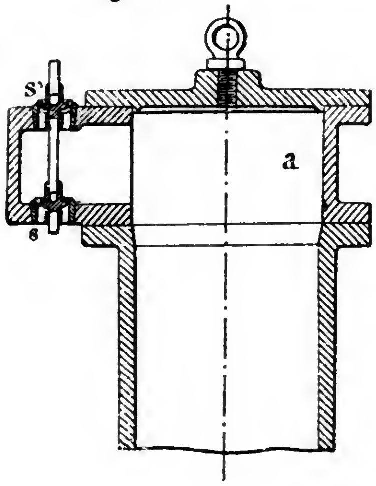
made equal to one-sixth of the diameter of the valve. Then:

$$L = 3.14 \times D'$$
$$h = \tfrac{1}{6} D'$$
$$3.14\, D' \times \tfrac{1}{6} D' = 2\, S$$

$$D'^2 = \frac{12\, S}{3.14} = 3.82\, S$$
$$D' = \sqrt{3.82\, S}$$

The steam admission valve should be balanced, and it should be placed as near as possible to the hammer, or better, immediately in front of the steam-chest, and should be so arranged that the hammerman can open or close it by a lever. Moreover, close to the valve or the exhaust port the steam pipe should open out into a reservoir of large dimensions in such a way as to give a very quick discharge and thus favor the descent of the hammer. This reservoir should then, by means of a pipe of large section, open directly into the air, and should have at its base a small pipe to permit the escape of condensed water.

Fig. 35



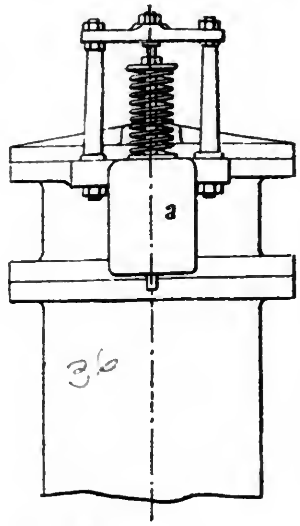


Fig. 36

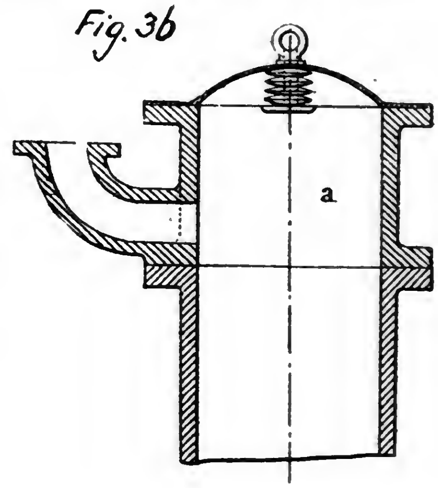
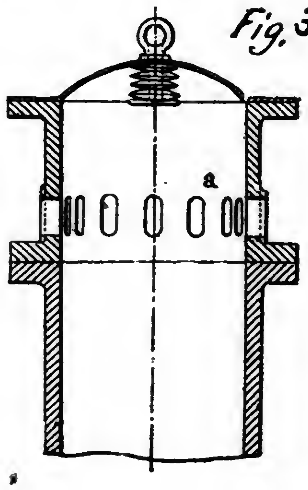


Fig. 37.



CHAPTER X.

SAFETY APPARATUS.

There is often used a safety apparatus, which is shown in fig. 35: it is composed of a cylindrical part a placed above the cylinder and closed by a cover. This part a carries two valves; the one S below is free on its seat, and the upper S' is held to its seat by springs whose tension can be regulated at will. This upper valve permits the escape of compressed air. The piston in descending draws in the air from the outside through the valve S, and this air is compressed above the piston, in its ascending course, in such a way as to form a cushion, preventing any accident in the case of any breakage of the piston-rod;

moreover, its action is added to that of the hammer in a descending course.

This system, however, has never worked very well, and has gradually been abandoned by builders. Some have

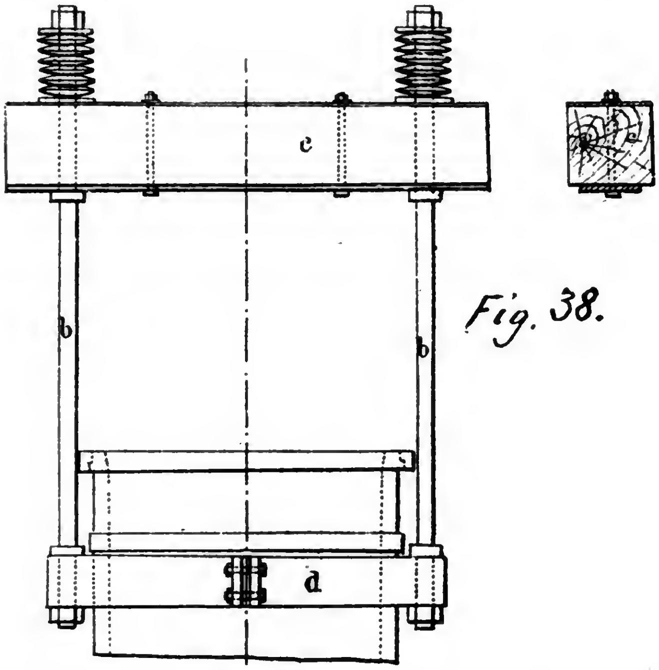


Fig. 38.

done away with the valves and have replaced them by a tube which serves to allow the steam to escape into the air should the piston-rod break, as shown in fig. 36, but the section of this tube is so small that it is not sufficient to permit the escape of the steam, and very often the piston strikes and breaks the upper cylinder-head. This system has also been generally abandoned.

The third arrangement is this: On top of the cylinder is a box or additional cylinder *a*, which has below a series of holes around its circumference, as shown in fig. 37, permitting the steam to escape freely into the air, in case the piston-rod should break. Moreover, the compressed air which is found above the piston holds it and keeps it from being thrown out.

The upper cover should be of wrought iron and not of cast iron, and the handle or ring for working it should carry on its lower end several springs in order that shocks which may be produced will not break the cylinder-head.

There is also to be counted among safety apparatus an arrangement frequently employed, which permits us to dispense with the part of which we have spoken, and which is placed above the cylinder. This arrangement has the advantage of being very simple; it makes the lubrication of the piston easy, especially when tallow is employed, and makes it possible to control the upper part of the piston at any time and without displacing anything. This apparatus is composed of an iron collar in two parts, tightly coupled together by bolts outside of the cylinder, and bearing against a ring cast on the cylinder. On this collar are fixed two bolts *b b*, which support a cross-bar *C*, of oak wood, protected above and below by heavy plates or channel irons. Above this cross-bar and held by the same bolts are several springs kept up by screws, as shown in fig. 38. The distance from the top of the cylinder to the wooden cross-bar should be equal to the length of the piston-rod below the piston, increased by 0.150 to 0.300 meter, in order to allow the steam to escape before the top of the piston strikes the cross-bar; in this way, there being no longer any pressure below the piston, the block has only to take up the shock resulting from the force of inertia of the moving parts. The diameter of the bolts *b* is calculated by the formula

$$d = \frac{D}{20} + 0.020.$$

In this *D* represents the diameter of the steam cylinder.

CHAPTER XI.

PISTON-RODS AND PISTONS.

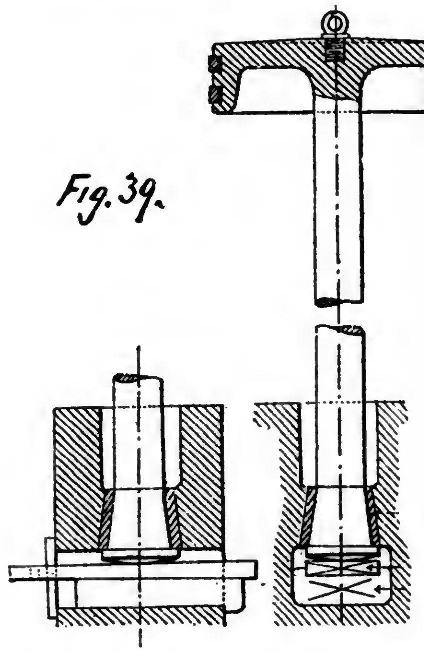
The piston-rods and pistons are sometimes made of iron and sometimes of steel. When the piston is forged in one piece with the rod it is generally made of iron, and it makes then very commonly the form shown in fig. 39.

These forgings—that is, the piston and piston-rod forged in one piece—are, however, used less and less every year, partly because it makes a difficult and expensive forging, and partly because steel castings are now made of so excellent a quality and so free from faults and blow-holes. When steel is used there are generally two distinct parts, the piston properly so called and the rod.

Fig. 40 shows the arrangement usually adopted in small hammers. The piston is bored out tapering, and is put upon the rod hot. It is held in place by means of a nut, which prevents any movement, and which is kept from working loose by a jam-nut or a pin.

Fig. 41 shows the arrangement used in the Steel Works of the Marine for the piston of the 80-ton hammer; it is bored out tapering and forced on hot, and rests on a col-

Fig. 39.



lar forged on the rod. It is held to the rod by a round nut put on warm and then very tightly screwed up. This nut, in order to secure additional safety, is held in place by a key driven into a key-way cut in the end of the rod above the portion which is threaded for the nut.

Fig. 42 shows the arrangement used by M. Arbel in all his hammers. There are three collars turned upon the rod upon which the piston rests. This piston is also forced on the rod hot, and is held on the upper side by a collar in two pieces, which is placed around a recess turned in the piston-rod, and is then held together by an outer ring or tire, driven on hot. This device has been used for a number of years with most excellent results.

In general the boring of the piston and the turning up of the corresponding part of the rod should be done with a great deal of care; the piston should always be put on the rod hot, and an allowance for shrinkage should be made of 0.0002 meter to each decimeter of the diameter of the rod.

The arrangement of making the piston and the rod in separate pieces, besides the greater economy, presents the further advantage that the piston-rod can still be used in case the rod should break—an accident to which large hammers are particularly subject.

The piston rings are made of refined iron or of mild steel; they should be turned up to a diameter somewhat greater than that of the cylinder, and should be sprung in in the same way as packing rings for ordinary steam-engines. The rings are cut diagonally, as from *a* to *b* in fig. 45. There are usually two or three rings on the piston, and

they should be put on so as to break joints in order to diminish the leakage of steam.

Many constructors now use steel for piston-rods. Until recently it was believed that mild steel was the best metal to resist shocks and vibrations. Steel, however, is a metal of many surprises, and recent experiments made in the

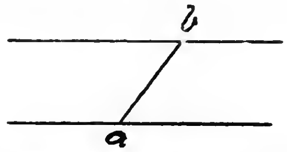


Fig. 45

United States by Mr. Metcalf, of the Crescent Steel Works near Pittsburgh, in connection with Professor Thurston, tend to show that this opinion is not correct, and that hard steel will resist vibrations better than mild steel.

These experiments have been continued by us in France on a number of rods annealed but not tempered, and with hammers varying from 1 to 10 tons; the results have fully confirmed the facts as stated by Messrs. Metcalf and Thurston.

The diameter of the rod varies according to the weight of the striking part of the hammer, the length of the stroke, the kind of metal to be worked, and also according to the temperature at which the forging is usually stopped. Consequently, the weight of the hammer remaining the same, the diameter of the rod must be increased as the stroke is increased and as the working temperature of the forging is lowered. The case is the same whetner we work iron or steel.

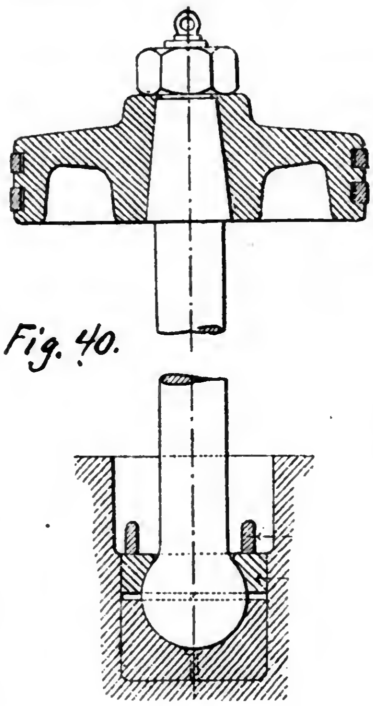


Fig. 40.

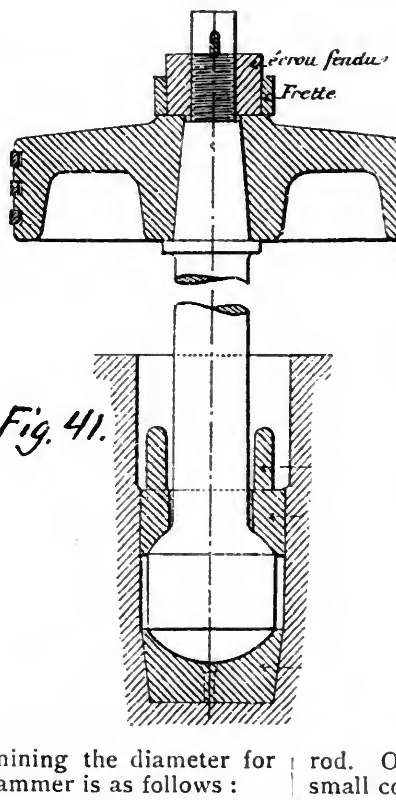


Fig. 41.

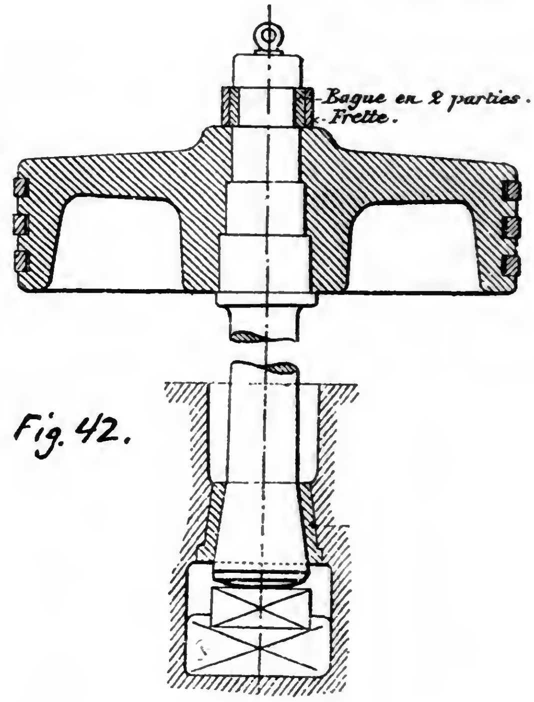


Fig. 42.

A practical formula for determining the diameter for the piston-rod of a single-acting hammer is as follows:

$$D = \sqrt{\frac{P}{K}} + 3.$$

Here D is the diameter required, in centimeters; P represents the weight in kilos. of the working parts, and K is a coefficient, which is taken usually at 60 for hammers from 1,000 to 15,000 kilos., and at 75 for hammers over 15,000 kilos. This formula is a variation of the formula used to determine the diameter of piston-rods for steam-engines, which, as we know, is as follows:

$$D = \sqrt{\frac{P}{K}} + 0.5.$$

The coefficient K has been diminished, and the constant has been raised from 0.5 to 3 centimeters. In this formula we have adopted a fixed ratio of 1 : 20 between the diameter and the length of the rod. Thus, in order to determine the diameter of the rod of a 10-ton hammer, we have

$$D = \sqrt{\frac{10.000}{60}} + 3 = 0.160 \text{ meter.}$$

The table below gives the results for the piston-rods of 24 hammers of weights varying from 1,000 to 100,000 kilos.

Weights of Working Parts.	Diameter.	Weights of Working Parts.	Diameter.	Weights of Working Parts.	Diameter.
Kilos.	Meter.	Kilos.	Meter.	Kilos.	Meter.
1,000	0.070	5,000	0.125	30,000	0.230
1,500	0.080	6,000	0.130	35,000	0.246
2,000	0.088	8,000	0.145	40,000	0.260
2,500	0.095	10,000	0.160	45,000	0.275
3,000	0.100	15.000	0.172	50,000	0.288
3.500	0 106	18,000	0 185	60,000	0.312
4,000	0.112	20,000	0.193	80,000	0.358
4,500	0.117	25,000	0.212	100,000	0.395

CHAPTER XII.

METHODS OF CONNECTING THE PISTON-ROD TO THE HAMMER.

Fig. 39 shows a method very generally adopted in France, consisting of a ring in two parts, made thicker above than below, in order that it may not slip upon the rod. Once in place, the lower end of the rod carries a small collar holding this ring in the hammer-block. The rod is then fixed in position by means of a key and a counter-key strongly driven in, one against another, in such a way as to prevent any displacement.

Fig. 42 shows the method employed by M. Arbel; it differs from that just described only in having the ring upon the collar and not upon the rod.

This system of keying is that adopted by Bourdon, and is, after all, the only one which has so far given uniformly good results.

Fig. 40 shows the method generally adopted in England and Germany; it consists of a block or socket in which is placed the lower end of the rod, which is turned up in a spherical form, and of a ring above, which is made in two parts and held in place by two strong keys driven through the hammer-block. This system allows some variations in the position of the hammer without bending the rod,

but, on the other hand, it is not so readily used for stamping pieces of large diameter.

Fig. 41 represents the method adopted by the Société Cockerill at Seraing, Belgium, for large hammers. The lower part of the rod rests in two spherical pieces held together by a cylindrical ring. This arrangement has the advantage of being more easily made than the preceding one, and also of taking less material out of the hammer-blocks.

On the upper end of the piston-rod there should be a hole bored and tapped out, in which there should be screwed a stout ring; this will make it easy to lift or handle the piston when it is necessary.

(TO BE CONTINUED.)

NOTES ON THE SEWERAGE OF CITIES.

(Translated from paper of M. Daniel E. Mayer, Engineer, in the *Annales des Ponts et Chaussées.*)

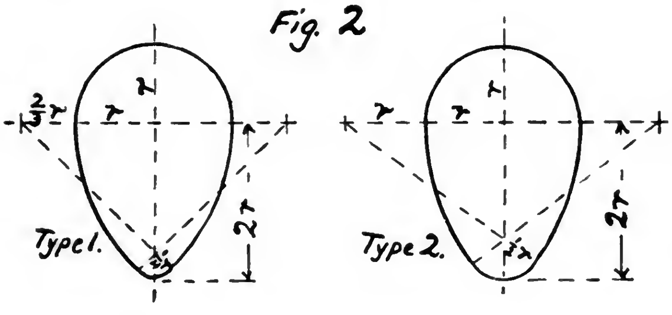
(*Continued from page* 313.)

VI.—BEST SECTION FOR SEWERS.

As to the transverse section of sewers, considering the great variations in the value of Q, in the formula above, between the ordinary and the maximum duty, the conclusion which we have drawn from these formulæ is that the best section is one having a circular form, the diameter being determined by the ordinary duty, but which is enlarged above in such manner as to have a sufficient capacity for the maximum volume of water. This is the definition of the ovoid or egg-shaped type, not like that which is used in Paris, where, in order to permit the passage of workmen, the bottom is made nearly flat, but such as is shown in the two following figures, representing types used abroad.

In type 1 the width at the widest part is $2r$; at the lower center, $\frac{1}{2}r$; the total height is $3r$; the perimeter, $7.84r$,

Fig. 2



and the total section, $4.46r^2$. The total discharging capacity (full) is:

$$\frac{3.363}{\sqrt{b}} \sqrt{r^5 I} = 5.80 \sqrt{r^5 I}$$

when $b = 0.33$

For type 2, the width at the widest part is $2r$; at the lower center it is r; the height is $3r$; the perimeter is $7.93r$, and the total section is $4.594r^2$. The total capacity (full) is:

$$\frac{3.494}{\sqrt{b}} \sqrt{r^2 I} = 6 \sqrt{r^2 I}$$

when $b = 0.33$.

Type 1 is most used, but type 2 has the advantage of a narrower base, and consequently is better suited for those cases where the ordinary duty represents only a small proportion of the total capacity which may be required. These oval, or rather ovoid, forms are theoretically best for large sewers with a variable duty, but in practice we should not hesitate to employ for small sewers circular pipes of glazed clay or stoneware, which, from their many excellent qualities—strength, smoothness of surface, resistance to the acids which are often contained in sewage water, cheapness of first cost and of maintenance, ease of cleaning, etc.—are in our opinion the very best.

Until lately this class of pipes was made only in England, but the industry has now been successfully established in France, particularly owing to the encouragement given for several years by the municipal service of Paris. They are also extensively made and used in America.

The laying of these pipes demands great care in placing and in the joints. An opening or man-hole accessible to workmen should be placed at each change of direction or fall in such a way that the pipes may always be placed in proper line and that changes may be properly marked. This class of sewers is particularly adapted to straight and regular streets; it would be more difficult to apply in narrow and crooked streets.

For larger streets an excellent solution has been adopted in Berlin, where four-fifths of the sewers are of the earthenware pipes; this is to place two in each street, one under each sidewalk. This arrangement avoids the necessity of disturbing the roadway and reduces very much the length of the house connections, which can also be given sufficient fall to keep them clear, even when the sewer, as is often found necessary in so flat a place, is very near the surface of the ground.

Experience shows that it would not be well to employ a pipe sewer, which receives house connections, of less than 0.24 meter in diameter; on the other hand, in most places there would be no economy in using pipes more than 0.50 meter in diameter in preference to a small ovoid sewer like those used in Frankfort-on-the-Main, which are 0.62 meter in breadth in the widest part and 0.93 meter in height, made of beton.

M. Durand-Claye, Engineer-in-Chief of the sewers of Paris, who is very favorable to the use of these pipes as public sewers, has pronounced himself very strongly against the use of masonry sewers of small size. In spite of this high authority experience does not permit us to accept the principle without reserve, but in practice it will be generally both possible and advantageous to arrange the system in such a manner as to have only pipe sewers with small duty, with the exception of the principal collectors.

The use of pipes as indicated is the best wherever the duty does not require, taking into consideration the amount of fall, that the diameter should be less than 0.24 or greater than 0.50 meter. These sizes permit the passage of very considerable quantities of water in the higher parts of a system, where the fall is generally great.

The following table has been calculated with the value $b = 0.40$, assumed in calculating the sewers at Berlin.

DUTY OF SEWERS (IN LITERS PER SECOND) FOR DIFFERENT DEGREES OF FALL.

Diameter of Sewer.	Fall in meters per kilometer (1,000 meters).				
	20	15	10	5	1
Meters.	Liters.	Liters.	Liters.	Liters.	Liters.
0.24	78	69	55	39	17.5
0.27	105	92	74	53	23.5
0.30	137	120	97	68	30.6
0.33	174	152	123	87	39
0.36	216	189	153	108	48
0 39	264	231	187	132	59
0.42	317	278	224	150	71
0.45	377	331	267	189	84
0.48	443	389	313	222	99
0.51	516	352	365	258	115

The fall of 1 in 10, which is greater than any known in Berlin, can be obtained in most of the cities of France for pipe sewers, where the starting-point can be placed near the surface. With this fall a pipe of 0.50 meter in diameter will carry 0.365 cubic meter per second, which, adopting the calculation for rain water which we have given heretofore, corresponds to an area of 9 hectares served, or, if two-thirds of the area is in gardens, cultivated or unoccupied land, of 27 hectares. This surface will be much more increased if we adopt the system just mentioned of two sewers in each street.

It may be assumed then that the greater part of the system of city sewers may be made of these pipes, and that it will be only for the heavy duties required of the collecting or main sewers that the building of masonry sewers will become necessary.

At Frankfort-on-the-Main the ovoid pipes of type 2 shown above, of 0.93 : 0.62 diameter, form the greater part of the system, and, as has been proved, they can be kept clean without difficulty and with small expense.

It is not the same at Berlin, where there are masonry sewers of 0.90 meter in height, and where the fall is very light; in spite of caution taken to prevent the accumulation of sand in sewers, it is rapidly deposited in these galleries, and it is necessary that workmen enter the sewers to clean them out; which, in so small a passage-way, is extremely difficult and unpleasant work. The same inconvenience due to sand is present in pipe sewers, but results in less trouble, for in these it is sufficient to use brushes, drawn through the pipes by cords, where the pipes show a tendency to fill up.

Fortunately, however, the unfavorable conditions found at Berlin--this almost entire lack of fall—are very rarely found in French cities.

A general collecting sewer of type 1, of 2.00 : 1.66 diameter, with a fall of 1 millimeter to a meter and full only up to the widest part, will carry off 170 cubic meters per second; this is more than three times the ordinary duty of a city of 150,000 people. We may adopt these dimensions in a city of 100,000 people, even where population is increasing with some rapidity, and a work of this size will carry off easily not only the dirty water, but also the overflow from the average rains.

If we consider that at Paris the smallest type actually used in the less important streets is 2.30 meters high, it will be seen that, without disapproving the conclusions of the Parisian service, it will be best to warn other cities against imitating this example.

The general collecting sewers of very great size, like those existing in Paris, are not required in other cities, even where the conditions of fall are so extremely unfavorable that an ordinary ovoid sewer of 3 : 2 meters in diameter will not suffice to carry off three times the ordinary amount. Now a sewer of the dimensions indicated, having 0.40 meter fall per kilometer, will carry off when full to the widest part 2.5 cubic meters per second, which corresponds to an ordinary duty of 0.800 cubic meter and to a population of 250,000 people. The conditions of fall in this case are not unfavorable, since $Q\ I^2 = 0.800 \times 0.40^2 = 0.128$, and $0.128 > 0.10$.

VII.—ACCESSORY WORKS.

The accessory works of a system of sewers are the street traps, the man-holes, works especially intended for ventilation, and the arrangements made to clean out the sewers by flushing with water.

The street traps or openings should be made in such a way that the water running from the streets and the gutters may flow into a sort of well or cistern, from which it passes into the sewer through a siphon. The use of the siphon here is not to prevent the escape of air from the sewer into the street, but to prevent the introduction into the sewer of solid bodies, which might obstruct it. In order to attain this object many different plans have been devised in England and Germany, but we do not think that any of them presents sufficient interest to require particular description.

Man-holes are vertical shafts large enough to permit the descent of workmen, and having a vertical axis meeting the horizontal axis of the sewer. By an arrangement of valves it is possible to fill one of these man-holes with water, and by opening them quickly to permit the accumulation of water to discharge itself into the sewer and produce a rapid current in the section immediately in front. These works—valves, gates, etc.—intended to clean out the sewers are comparatively small, and belong rather to the cost of maintenance than to that of construction.

VIII.—VENTILATION AND HOUSE CONNECTIONS.

A very important question is that of ventilation.

Is or is not the exchange of air between the sewers and the outer atmosphere to be avoided? This is a grave question, over which there has been much controversy, and upon which medical scientists do not yet possess precise information. While there is no doubt whatever that water carries germs of infection, and that the use of contaminated water either by man or by animals is very dangerous, we do not yet really understand the part played by the air in carrying these same germs, and we cannot actually see with how much danger the diffusion of the air of the sewers into the atmosphere is attended. Let us remark here that as to the exchange of air between the sewers and house, with its closed rooms, there is no discussion; such exchange should be prevented by siphons, both in the interest of the sewers and the house. We are now only speaking of the exchange of air between the sewers and the street.

If such exchange must be absolutely prohibited, we would be obliged to use for the flow of water passages made perfectly tight, and cleaned when necessary by mechanical means. Upon this principle have been founded several systems of sewerage of different kinds, but all based on the same principle, which we have called the separate system. Except in certain exceptional cases we have rejected this separate system, and on general principles we would continue to reject all forms of this system, in which an already difficult question is still further complicated with additional demands, which seem to us excessive and useless.

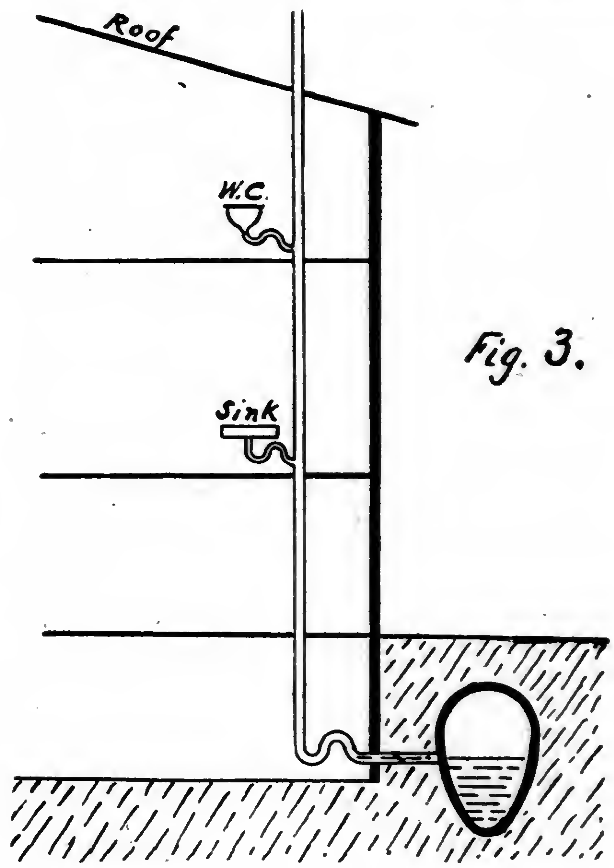


Fig. 3.

Whatever may be in fact the true theory of carrying the germs of infectious disease by the air, we believe it safe to assume that if proper measures have been taken to insure in the sewers a regular flow, and consequently to avoid all cause for stagnation and fermentation, there will be no danger in permitting connections between the sewers and the outside air.

This principle granted, it will be our part not to prevent but to develop, as far as possible, the communications between the sewers and the outside air. If the air of the sewer becomes confined and putrid it will have a bad effect on the branches into the house. Moreover, in a system where the smaller portions are obliged to receive much rain water, accidents are to be feared if the air of a sewer is not provided with sufficient escapes.

In the Parisian system ventilation is made possible through the street openings.

In the system which we have shown (fig. 1) the street openings are provided with siphons and can be counted upon for ventilation. The man-holes, if the covers are pierced with holes, may fill a useful part, principally to permit the escape of the air of the sewers driven or forced out by the rain water.

It is, however, principally through the house connections that the ordinary ventilation of the sewer should be secured.

A pipe provided to carry down the rain water should not, in our opinion, be provided with a siphon unless it opens below a window in the roof; and one precaution which should be taken, if the arrangement of the roof is such that solid bodies may be washed down, is to provide the top of the pipe with a grating to prevent them from being washed down into the sewers. This pipe, however, while it would ordinarily serve as a ventilating pipe, would not answer the purpose in rainy weather.

The escape pipe for the waste water, if it is carried up through the roof, will serve as a ventilator if it is not closed at its lower end by a siphon. Theoretically it is enough if the siphon is connected with each point of escape in the house—sinks, water-closets, etc.—which leaves to the main pipe its functions as a ventilator; practically, in the interest of both the house and the sewer, it is much better to place at the base of the waste pipe a siphon as an additional precaution to prevent solid bodies from being carried into the sewer, and in this case there should be immediately back of the siphon a special pipe intended for ventilation only.

It is a very good plan, wherever it is possible, and especially in the case of factories and workshops, to carry a pipe from the sewer to the base of the chimney of a steam boiler.

At Frankfort-on-the-Main the engineers considered it necessary to build at high points ventilating towers 35 meters in height.

But considering that in summer, when every one is complaining of bad smells, the air of the sewers, being cooler than that outside, will escape only by diffusion, we believe that it is better to depend for good ventilation on a large number of points of contact between the two atmospheres, obtained by depending upon the house pipes. It is not without interest, before quitting this subject, to remark that by increasing the diameter of sewers we increase the quantity of vitiated air, and, in consequence, from this point of view also, large sewers have anything but an advantage.

The preceding considerations leave us little to say on the question of house connections, and engineers cannot do better than to refer for models to the very excellent dispositions now made by the municipal sanitary service in Paris, in all works made under its direction. In replacing the large pipes formerly used by smaller pipes there is an improvement both in the freer escape of water and in the reduction of the first cost. The precaution of aerating the siphons so that they shall not be washed out by the fall of water from the upper part of the same pipe is important. In low places where, in case of heavy rains, backing up of the water in the sewers is to be feared, we can use very well a sort of valve opening from the house outward toward the sewer; this works very well in Berlin, where it is very generally used.

(TO BE CONTINUED.)

An English Branch Railroad.

As an example of English construction we take from the London *Engineer* the following description of a short branch line lately built by the Midland Company in Yorkshire, which is intended chiefly for local business, although it also completes a loop line from Leeds to Skipton.

Though barely 12 miles long, the Skipton & Ilkley line, as we shall see farther on, has necessitated the construction of a great variety of interesting engineering works. The extremities of the line are practically at the same altitude—viz., 320 ft. above sea-level, but Skipton being in Aire Dale, while Ilkley is in the valley of the Wharfe, the intervening ridge, some 200 ft. higher, has to be crossed. The gradients of the line, therefore, are not particularly good. From Skipton to the summit, nearly four miles, we climb gradients varying from 1 in 90 to 1 in 240, while from the summit down again to Ilkley the ruling gradient is 1 in 100.

The line certainly has no claim to being called a light railway. On its 12 miles will be found one tunnel, three viaducts, 19 public roads, or canal bridges, 45 occupation bridges, some heavy work in the way of retaining walls and culverts, and nearly a million and a half cubic yards of cutting. The line is well laid out, and in designing the works, due regard has evidently been paid to economy. On the other hand, there is nothing to be seen of the cheap-and-nasty style. The work has been well done, the masonry being particularly good. Here and there on the slopes symptoms of slips can be seen, especially in the bad, peaty ground near Embsay; but they were taken in time and properly supported and drained, with the result that no slip of any consequence is now to be found on the whole line.

The accompanying illustration shows the Lob Ghyll viaduct which is in the Wharfe Valley, where the line runs along the hill-side. Lob Ghyll is a deep gorge in the hill-side, which has been cut through the Yoredale shales by the action of the stream; the line is carried over this ravine, which is one of the most beautiful spots in the neighborhood, by a masonry viaduct of five spans 70 ft. high. The arches are segmental, 30 ft. span, with a rise of 12 ft.; the piers are 4 ft. thick at top under the impost, with a batter of 1 in 26 at the ends, and 1 in 40 on the sides. The masonry is snecked rubble of sandstone from the Horsforth quarries, and is a good specimen of its class; the whole of the stonework is rock-faced, the impost, cornice, coping, etc., having a simple chisel draft round the angles and arrises; the viaduct thus harmonizes, as much as any modern structure can, with the lovely scenery surrounding it.

Chrome Pig Iron and Steel.

(Abstract of paper by M. Brustlein, Unieux, France.)

ALLOYS of iron and chromium, containing generally more or less carbon, have been known for a long time as products of the laboratory, but I believe that to the United States is due the first introduction of chrome steel for industrial purposes; at any rate, when, in 1875, I had commenced my experiments in France with the manufacture of chrome iron and steel, I had read that in the United States chrome steel of considerable strength had already been manufactured.

After a series of experiments, which were carried out at the works of Unieux, we commenced, in 1877, to supply chrome steel regularly to our clients; and since that date the use of chromium has become more and more extended at our works. As soon as several other French works became aware of the results we had obtained, they began to imitate us. I believe, however, that we were the first in Europe to show what could be attained with chrome steel. At Unieux, we produced, in crucibles, all the ferro-chrome that was necessary for the steel that we manufactured; but to-day there are several French works that produce chrome iron in the blast-furnace, although we believe that up to the present time the highest percentage of chromium contained in chrome iron made in the blast-furnace has been 49 per cent.

From observation and analysis of a number of specimens submitted, it will be observed that chromium and ferro-chromes possess the property of combining with large percentages of carbon, and that their general appearance varies more according to their percentages of carbon than according to their percentages of chromium. Both chromium and ferro-chrome appear to be able to combine with larger proportions of carbon than either manganese or ferro-manganese can do. On the other hand, however, the ferro-chromes, whether highly carburized or not, do

not appear to crystallize in plates or in large facets like spiegeleisen, and when they show a crystalline fracture it assumes the form of needles or very small facets. This distinguishing difference between chromium and manganese is probably not without some influence on the action which either of these metals exercises in steel. In ferro-manganese, when the percentage of manganese reaches about 30, the iron combined with it loses its magnetic properties. It differs in that respect from ferro-chrome. The iron which the latter contains retains the property of being attracted by the magnet, even in ferro-chromes containing as much as 65 per cent. of chromium. I am of opinion that iron containing chromium can be used with advantage in founding such a metal as may be required to possess hardness and a high capacity of resistance, such as rolls for rolling-mills, etc.; but in such a case it would be necessary to limit the percentage of carbon, as chrome iron with a high percentage of carbon appears to be always brittle.

Chromium appears to have little tendency to combine with copper, with a view to the production of bronze. In a specimen showing the results of an experiment made in order to obtain a chromium bronze, the fracture of the bar indicates a great absence of homogeneity in the metal obtained.

The ordinary ferro-chrome contains usually from 48 to 53 per cent. of chromium, and from 7 to 8 per cent. of carbon. With this composition, ferro-chrome combines with variable proportions of silicon, often exceeding 2 per cent.

Specimens of silico-chrome contain 47 per cent. of chromium, 7 per cent. of carbon, and 5.4 per cent. of silicon.

CHROME STEEL.

In the manufacture of steel, one can make use of very variable proportions of chromium. Thus, for example, we have ascertained that a metal containing 2 per cent. of carbon and 12 per cent. of chromium may be forged, and may be classified under the head of steel.

The presence of chromium in steel increases its resistance or tenacity. Thus, in two varieties of steel having the same percentage of carbon, and differing only from each other in so far as the first contains chromium and the second none, the first will have, besides, a notably higher tenacity, as well as a considerably higher resistance of pressure. Steel containing chromium, and properly annealed, will always be a little harder to work in the lathe or on the surface, and the difference in this respect will be increased according as the percentage of chromium is raised. This property renders chrome steel less suited to the manufacture of articles that require a complicated mechanical finish, such, for example, as milling tools.

Chrome steel contains usually from 1.5 to 2 per cent. of carbon, as noted above.

If the two varieties of steel have been suitably manufactured and treated, they will be found equally well adapted to the process of tempering. In chrome steel, however, the temper penetrates to a greater depth. This fact I attribute to the great affinity of chromium for carbon favoring the dissolution of the latter in the metal, and thus maintaining it with greater readiness in the dissolved state.

Before being tempered, the grain of chrome steel differs very little from that of other steel with the same propor-

LOB GHYLL VIADUCT, YORKSHIRE, ENGLAND.

tion of carbon. In both cases, the fineness of the grain depends mainly on the content of carbon, but on being fractured the first-named is always rather more fibrous.

As a result of being tempered, the grain of chrome steel becomes much finer, and if the percentages of carbon and of chromium are a little raised, the fracture, after tempering, becomes almost vitreous, as in the case of steel containing a high percentage of tungsten.

Chrome steel scales with much greater difficulty in tempering than ordinary steel, so that if we are to judge of the degree of reheating by its appearance, it is necessary to rub the tempered part, so as to remove the adherent film.

If chrome steel is too much heated in the process of tempering, the grain becomes more and more marked; and when it is altogether burnt, the fracture becomes quite crystalline, and the grains, brilliant in appearance, do not readily adhere to each other.

Under the hammer, chrome steel behaves quite as well as ordinary carbon steel. In the process of being cold drawn, however, it is notably harder.

Speaking generally, chromium has a less hardening tendency than manganese on highly carburized steel, but it imparts more tenacity, and the tendency to crystallize by excess of heat is not so great.

Manganese steel works better hot under the hammer than chrome steel, but manganese steel works particularly well. Again, manganese steel generally welds with great facility, while chrome steel welds badly, or not at all.

It has been thought that ferro-chrome could be substituted for ferro-manganese as an addition at the end of the Bessemer or the open-hearth process, but it is certain that the two would not act in the same manner. Ferro-chrome may be readily used as a recarburizing agent, but its oxide does not form a fusible combination; while manganous oxide forms with the silica a readily fusible silicate, which shows itself at the surface of the bath. Chromium, on the other hand, forms an oxide, which is infusible at the temperature of steel, and which does not combine to form a fusible slag. With steel in a state of fusion, there is a tendency to burn in contact with the air. It appears to combine with the oxide of iron. The carbon of the steel is more or less burnt in the immediate neighborhood of the part oxidized, and retains with itself in the still liquid steel the impurities produced. This causes deep veins to appear in the ingots, which no forging at a sweating heat can cause to disappear. This is one of the difficulties that are presented in the treatment of chrome steel. That difficulty is more or less increased according as the steel produced is more or less soft, and as its content of chromium is higher or lower.

The great facility with which chromium oxidizes at high temperature is again shown during the ulterior working of chrome steel. In the reheating furnace, this steel takes a layer of oxide, which is both stronger and less easily got rid of than in ordinary steel. It is this characteristic that renders it difficult, if not impossible, to weld two pieces of steel which contain a notable proportion of chromium.

Having regard to the properties already described, it is easy to understand that it will be equally impossible to obtain a product of a satisfactory character by the puddling of chrome pig iron. The pieces of metal which ought to form the ball take up a layer of infusible and more or less closely adherent oxide, which is not got rid of in the process of shingling, and which prevents the pieces of metal from welding.

For these reasons, I have never attempted the puddling of this description of metal, and I am convinced that if the puddling of a variety of iron containing a notable proportion of chromium were attempted it would fail.

The use of chromium in steel does not exclude the simultaneous employment of a certain proportion of manganese, of silicon, or of tungsten. Thus in practical working many kinds of combinations may be provided for.

I will conclude by giving the details of some experiments which have been made with test-pieces in the presence of the representatives of the principal French railroad companies with a chrome steel having about 0.7 per cent. of carbon. In this experiment we used a bar of 90 × 11.9 millimeters. From this bar we cut an end piece, which was annealed, and from that end piece we cut three test-pieces, No. 1, No. 2, and No. 3. These were turned to 9 mm. diameter, and a length of 75 mm. between the shoulders. Tensile tests gave the following results:

	No. 1. Annealed.	No. 2. Annealed.	No. 3. Tempered in Oil and Annealed Dark Red.
	Kilos.	Kilos.	Kilos.
Elastic limit per square millimeter.......	40.2	43.3	140
Ultimate tensile strength per square millimeter..............	73.0	70.8	150
Elongation per cent. per square millimeter	17.9	21.2	6.2
Relation of the ruptured to the original section.....	0.308	0.333	0.708

From the same bar we cut a piece one meter long, which we bent hot to a head of 100 mm., tempered and annealed. This piece was placed on a weighing-machine, and loaded in the middle with increasing loads, and after each addition the load was taken off again, in order to determine whether the test-piece had resumed its original form. Each charge was measured. Under a load of 1,540 kilos. in the middle, the piece retained its original form, and permanent set has only been produced with 1,580 kilos. Under a pressure of 2,000 kilos. at the center the piece showed a counter-bend of 53 millimeters.

THE NEW SHIPS FOR THE NAVY.

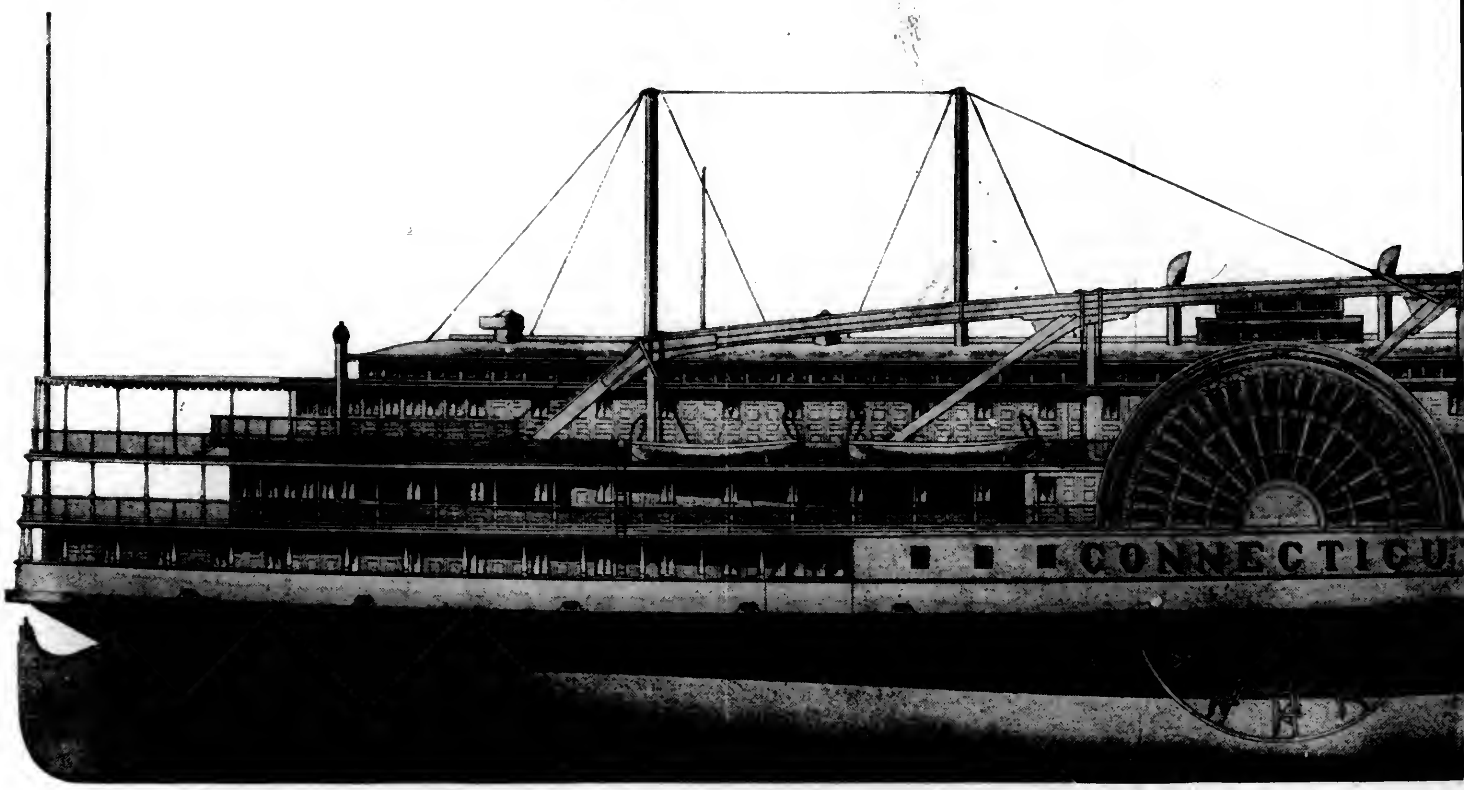
(From the *Army and Navy Register.*)

The shipbuilding programme in the naval bill, as reported, provides for four vessels as against six last year, but the amount of displacement tonnage in the four ships of this bill is 19,000 as against 23,000 tons in the six ships of 1887. The estimated cost of the four is to be $7,700,000, as against $8,768,000 for the six ships. It will be noticed that the average cost of last year's ships was about $370 per ton of displacement, while in this year's vessels an average of $400 per ton is allowed.

This is because the ships now provided for are to be more heavily engined than their predecessors were, so far as the unarmored vessels are concerned, while the single ironclad provided for in this bill will be almost as powerful as both of last year's armored ships combined. Some allowance has also been made by the committee for probable enhancement of the cost of material caused by elevation of the standard of tests in some particulars, which Secretary Whitney has in contemplation. It may also be said that there is a disposition among members of the House to increase this programme by adding another 3,000-ton ship, making three instead of two, as reported in the bill. This would bring the bill nearly up to that of last year in amount of tonnage, and slightly ahead of it in expenditure.

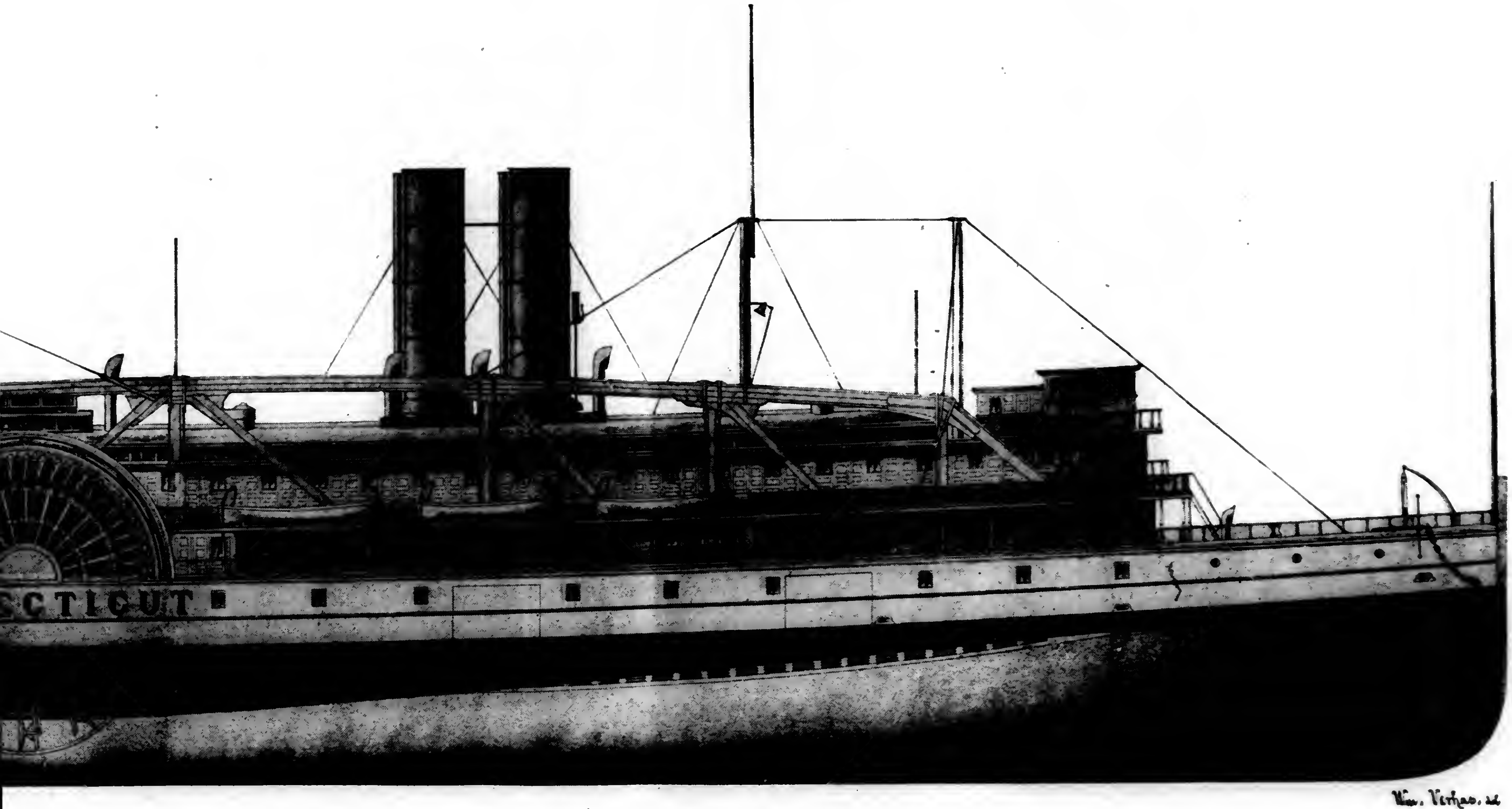
The ironclad provided for is to be of 7,500 tons displacement, and the Secretary hopes to get a guarantee of 17½ to 18 knots speed for her, in case she should be built by contract. It is well known here that tentative general designs for her construction have been provided by the Secretary, with the advice and assistance of one of the most eminent naval architects of the age, and these designs are pronounced by experts, who have had opportunity to examine them, to constitute the most advanced type of armored seagoing battle ships.

The large unarmored ship described in the bill as of "about 5,300 tons displacement" is intended to be to a great extent a duplicate of the famous *Reina Regente*, lately delivered to the Spanish Government by Thomson & Co., on the Clyde, and which is the fastest as well as most powerful armed cruiser now afloat. The speed developed by the *Reina Regente* on her official trial was 20.8 knots per hour in a two hours' run. And on her first run out to sea she logged over 19 knots an hour for several hours consecutively, which, it is needless to say, has never been equalled by any other vessel of any description. The law requires a guarantee of at least 20 knots for her American counterpart.



STEAMER

DESIGNED BY GEORGE B. MALLORY FOR T



TEAMER "CONNECTICUT."

LLORY FOR THE PROVIDENCE & STONINGTON STEAMSHIP COMPANY.

No special design has been determined on for the 3,000-ton ships provided for. They may be built on departmental plans or on plans offered by shipbuilders in connection with special bids, as was done last year. They will necessarily be of about the same general dimensions as the *Boston* and *Atlanta*, but of quite different metal, while their H.P. will be at least two and a half times greater than the power of those vessels. They will not carry as heavy guns as are mounted on the *Boston* and *Atlanta*, but their secondary batteries of rapid firing and machine guns will be much more powerful and effective. The law requires these ships to make 19 knots trial speed. It is generally agreed by naval officers that this 3,000-ton class is to be the most useful for general purposes, and will, when fully developed, form the bulk of our cruising fleet. Practically they will occupy a rank in the new navy corresponding to that held in the old fleet by the *Hartford* and *Brooklyn* class of vessels.

It is expected that efforts will be made to secure some modification of the existing law with reference to the physical qualities of the material to be used in construction. The present law requires a minimum of 60,000 pounds tensile strength, with 25 per cent. of elongation in all steel used for the frames and plating of hulls. This requirequently compelled the rejection of the very best quality of ment has hampered the Department somewhat, and has fresteel, on account of falling a few pounds short of 60,000 in tensile strength, notwithstanding that it exceeded 30 per cent. in elongation and was in every respect admirable hull material. For these reasons a proposition will be made to alter this clause of the law so as to make it read "steel of domestic manufacture and of the best attainable quality," leaving the details to the experts of the department.

"There need be no apprehension," says Captain Phythian, lately Chief Steel Inspector, "that the standard will be lowered. The tendency is constant in the other direction. But the law, as it stands, leaves an inspecting officer absolutely no margin for discretion, and precludes the exercise of mechanical judgment as to the real value of a heat of steel the moment its test pieces show the least deviation of tensile strength below 60,000 pounds."

It may be remarked here that another evil of which manufacturers and contractors complain is the frequent changes of inspecting officers at the steel mills and shipyards. There have been three chief steel inspectors within a year and also three changes of superintending constructor at Cramp's yard during the same period, with still another in prospect. Speaking of this, the engineer of Cramp & Sons resident here says that the effect of these frequent changes is to turn the mills and shipyards into schools of instruction for naval officers in metallurgy and modern shipbuilding, and that while this might be advantageous if they were left long enough in one place to enable them to complete the course, the practice thus far has been to detach officers from inspection duty just when their experience began to be valuable. Much inconvenience, and, in some instances, actual delay, has resulted from this cause.

It is understood that Secretary Whitney desired the committee to provide for two training ships and two or four light draft cruisers for special service on the Chinese coast and rivers, to replace the old *Monocacy*, *Palos*, etc., but they were not incorporated. For some reason not yet explained it is expected that they will be added to the bill in the Senate through an amendment.

Work on the new cruiser *Baltimore* at the Cramp Yard, Philadelphia, has advanced so far that the ship will soon be ready. The gunboat *Petrel* was to be ready for launching about August 1; the *Baltimore* will be ready soon afterward, everything being in good order.

The *Charleston*, built by the Union Iron Works in San Francisco, was launched July 18, and work upon her will be pushed as quickly as possible.

The Pittsburgh Steel Casting Company has the contract for making the stem and stern-posts and other heavy castings for the armored cruiser *Maine*. The stem-post will weigh about 17 tons, and is to be cast in one piece.

THE STEAMER CONNECTICUT.

For a number of years past the boats running upon Long Island Sound have disputed with those on the Hudson the claim to be called the finest and most convenient passenger boats in the world. Additions have been made to the fleets owned by the different companies until such vessels as the *Bristol*, the *Rhode Island*, and the *Pilgrim* have become known all over the country. The latest addition to the Sound fleet is the steamer *Connecticut*, which has been built for the Providence & Stonington Steamship Company from the designs of Mr. George B. Mallory, of New York, and which is now nearly ready to take her place on the line between New York and Providence.

The *Connecticut* differs from her chief rival, the *Pilgrim*, in having a wooden instead of an iron hull; she differs also almost entirely in arrangement and details from most other steamers on the Sound. The design of her hull shows a bow line 171 ft. long, or nearly half her length, then a short parallel body, and then stern lines sharper than those usually seen in other boats of this class. Under this plan the center of displacement is thrown much further forward than usual, and, indeed, so far that all freight may be stowed forward of the main deck saloon and none will be carried aft of that point.

The principal dimensions are as follows: Length over all 358 ft. 6 in.

Length on 11-ft. load line, 345 ft.
Beam outside of hull planking 48 ft. 2 in.
Extreme width over guards, 87 ft.
Depth of hold, 17 ft. 3 in.
Extreme depth forward, 23 ft. 6 in.
Extreme depth aft, 20 ft.
Extreme height from bottom of keel to top of pilot house, about 61 ft.

The accompanying illustration, which is taken from the original drawing prepared by the designer, is a very excellent view of the vessel as a whole, and shows her general plan of construction with the outside arrangement of the different decks.

The hull of the *Connecticut* was built by Robert Palmer & Son in their yard at Noank, Conn., and is made in the most solid manner. The frames are of white oak and hackmatack; the keelsons and ceiling of yellow pine; bottom planking of white oak; the wales of yellow pine; main deck and beams of white pine. The floor timbers are filled in solid for 180 ft. of the length of the vessel. The hull is divided by five water-tight bulkheads, extending up to the main deck and entirely across the ship, without openings of any kind. The keel bolts are $\frac{7}{8}$ in. in diameter, of yellow metal, and clinched at the ends on composition plates flush with the surface of the keel. The stern-post is a white oak knee sided and molded 14 in., and fastened by 1-in. yellow metal bolt and clinch-rings.

In the lower hold, under the orlop deck, the first compartment forward of the collision bulkhead is fitted for chain lockers and dunnage rooms. Aft of these are store-rooms, water-tanks and other compartments in which are placed the machinery for working the electric lights. Under the main deck forward is the forecastle, in which accommodations are provided for the crew and the firemen. Aft of the collision bulkhead are the galleys and the pantry for the officers; then comes the lower cabin; then the space occupied by the boilers and the engines. Aft of the engine-room is the galley and pantry for passengers, then the main dining room. Aft of the after water-tight bulkhead the space is occupied by the "glory hole," in which are the rooms for the waiters.

Like the general plan of the boat, the arrangement of the upper decks and joiner work differs considerably from any boats now in use on the Sound. There is accommodation for passengers in the forward and after holds, where there is berthing capacity for about 200 persons. The main portion of the boat used for passenger accommodations is finished in a very substantial and elegant manner, but at the same time in excellent taste, without the profusion of superfluous ornament which is very often seen. The main passenger entrances or quarter deck is finished entirely in solid mahogany. The space aft of the main entrance, which is usually occupied by state rooms, is in this

boat taken up by a café, finished in the same style. This is intended to take the place of the bar-room usually placed forward, and will be conducted as a lunch-room and café, similar to those found in the best hotels.

At the stern, in the usual place, is the ladies' cabin. The ticket-office, coat-room, barber-shop, pantry, and store-rooms are found adjoining. From the after end of the café a stairway leads to the main dining room in the after hold.

The main saloon on the upper deck is reached by a stairway 15 ft. in width, rising from the forward side of the quarter deck. This saloon is 280 ft. long with a height of about 25 ft. from the floor to the top of the dome or roof. State-rooms are in two tiers; access to the second tier is given by a gallery running entirely around the saloon. The gallery rails and staircase are of polished mahogany. The state-rooms, of which there are 190 in all, are very handsomely finished and fitted up and are of varying size. They provide accommodations for 600 passengers.

The engine-room enclosure in the saloon is fitted with large plate-glass windows, and the whole interior of the engine-room is finished in polished sycamore, presenting a very handsome appearance. The cabins and the saloons are thoroughly ventilated, air being exhausted by machine fans located in the fire-rooms, and also through ventilating shafts from the main funnels.

Nearly all the cabin and joiner work was done by William Rowland, of New York. The painting, upholstering, furniture, and the electric-light fixtures in the saloon, together with the mahogany work of the main deck, were furnished by Herter Brothers.

The entire boat is lighted by electric lights, two complete dynamos of 800 lamps' capacity being provided, and all the electric fittings are made in conformity with the Navy specification. Electric call-bells and indicators are supplied throughout the boat; there is also steam-heating apparatus for use when required.

The *Connecticut* differs from most of the steamers on the Sound in her motive power as well as in general design and other arrangements. Mr. Mallory has abandoned the beam engine, which is so universally used; the type adopted is a direct-acting, oscillating, compound engine, with surface condenser.

The engine has a high-pressure cylinder $56\frac{1}{2}$ in. diameter and low-pressure cylinder 104 in. diameter, both being 11 ft. stroke, and both coupled directly to the main shaft. This shaft carries feathering paddle-wheels 28 ft. in diameter, which have 12 buckets 14 ft. wide and $4\frac{1}{2}$ ft. deep. The steam pressure ordinarily carried will be 120 lbs. The steam will be furnished by six gunboat boilers, each $12\frac{1}{2}$ ft. in diameter and 20 ft. 3 in. long. These boilers are placed three together and will be fired from two fire-rooms; over each is located a centrifugal fan 6 ft. diameter and 5 ft. face, supplying 30,000 cubic feet of air per minute.

The engines are expected to make about 25 revolutions per minute and to develop 4,500 to 5,000 H.P.; the expected speed which the boat can attain is 17 knots per hour. These engines are the largest oscillating engines ever built.

The total weight of the engines and boilers, including the water in the boilers, will be about 1,000 tons. The surface condenser has about 12,000 square feet of tube surface. There are two air pumps, four feed pumps, and two bilge pumps. All the auxiliary engines work in connection with a separate surface condenser entirely independent of the main condenser. The engine and machinery were built by the William Cramp & Sons Ship & Engine Building Company, Philadelphia.

The direct-acting engine takes much less room than the beam engine, and also weighs considerably less than a beam engine of the same capacity. It may be noted here that the boilers are entirely of steel, and that all the shell rivets were driven by hydraulic riveters. There are two smoke-stacks placed fore and aft, each 8 ft. 6 in. outside diameter.

The chains and anchors wil be handled by a steam windlass made by the American Ship Windlass Company. Steam-steering apparatus is also provided, and there are donkey boilers to supply the hoisting and other engines. The boat is fully provided with fire pumps, hose, and other usual precautions against fire.

It would be interesting to make a comparison between this vessel and the first steamer of the same name, which began to run between New York and Providence in 1822. Unfortunately no accurate description of that vessel has been preserved, but we are informed that she began her regular trips in July of that year, having for a few months previously been employed between New Haven and New York. The old *Connecticut* was owned by the Rhode Island & New York Steamboat Company and ran on alternate days with the *Fulton*. She was 150 ft. long, 26 ft. beam, and 200 tons burden. She had what was known as a "square" or "cross-head" engine of an old type, which has now entirely disappeared. Her boilers were of copper, the fuel used being wood, and so much of this had to be carried that there was very little space left for freight. In speed there was almost as much of a contrast as in size. On her first trip to Providence she left New York, June 4, at 4 P.M., touched at Newport and arrived at Providence at 8 A.M. on June 6, having taken 52 hours for the trip and having been actually about 40 hours in motion, as it is said she laid up $8\frac{1}{2}$ hours at Sands' Point and three hours at Fisher's Island, on account of a heavy easterly wind.

The old *Connecticut* did service on the Sound for a number of years, until replaced by a larger vessel, which in its turn gave way to a still larger one, the new *Connecticut* being the latest development of a long series of improvements.

Steam Sanding Apparatus for Locomotives.

THE accompanying engraving, taken from the London *Engineering*, shows the Holt & Gresham steam sanding apparatus for locomotives, which is manufactured by Gresham & Craven, Manchester, England, and has been adopted on several roads in that country. The advantages claimed for this arrangement over the old method of allowing the sand to pass from the sand-box to the track simply by the action of gravity are that the sand can be delivered at a high velocity directly to the point of contact between the wheel and the rail where it is needed; and also that the amount supplied can be perfectly controlled. It is further claimed that this apparatus is much more economical, as the sand is not liable to fall clear of the rail or to be blown off. The apparatus is constructed as follows:

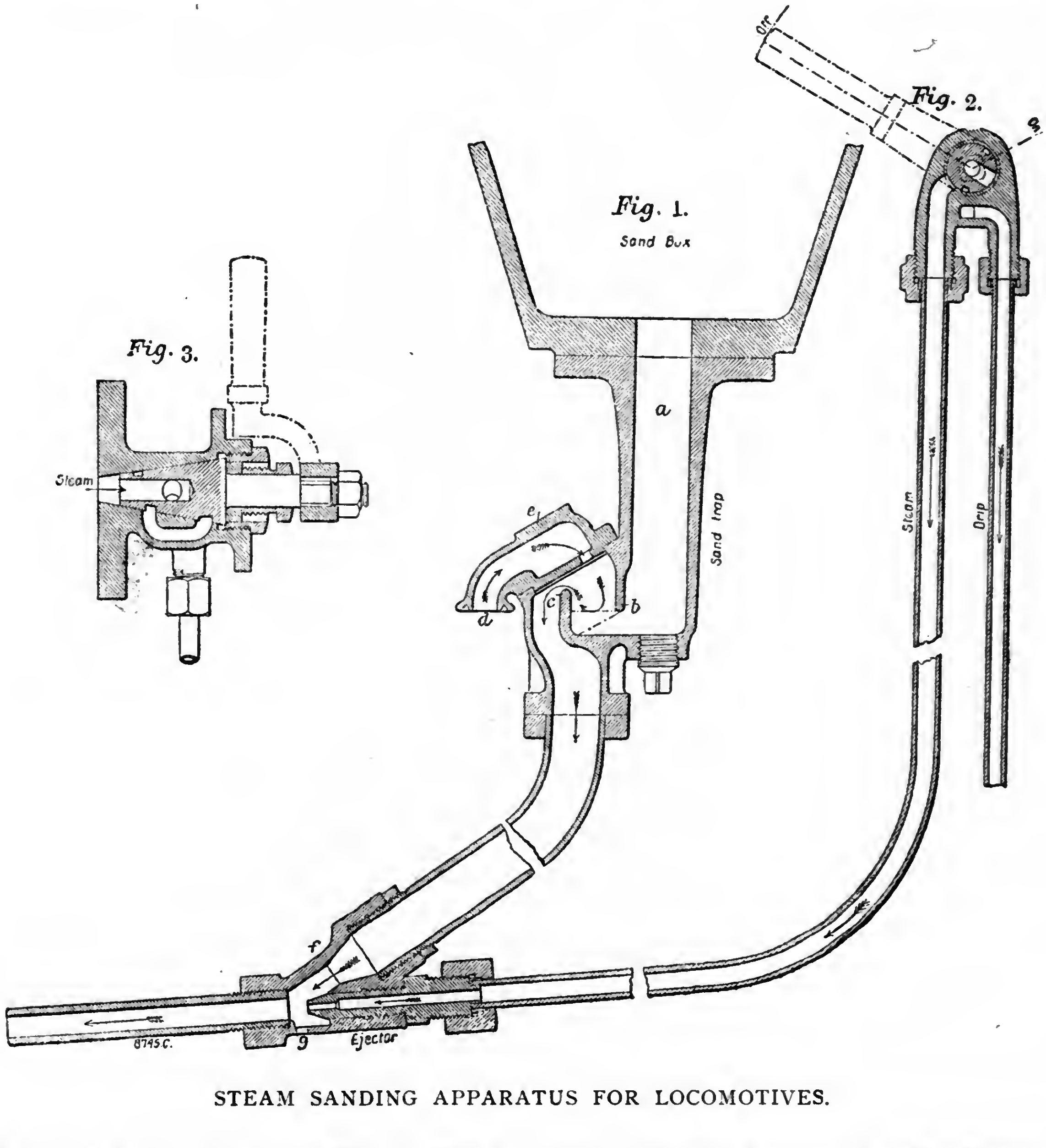
At the bottom of an ordinary sand-box is fitted a sand-trap at *a b*. The sand falls down the pipe *a*, and on reaching *b* passes through the opening shown, and were it not for the vibration of the engine, would take up a sloping position as shown by the inclined dotted line. Owing to this vibration, however, it finally takes the position shown by the horizontal dotted line, at which it remains till steam is turned on through the ejector shown at the bottom of the sand-pipe. When this is done the flow of steam produces a partial vacuum in the sand-pipe, causing air to be drawn in through the air inlet *d*. This air is deflected down on the sand, as shown by the arrows, and carries it with it over the weir *c* down the sand-pipe to the ejector, which blows it on the rail. The hole *g*, shown in front of the ejector nozzle, is to prevent sand accumulating there when steam is shut off, which would otherwise occur. The valve through which steam is admitted to the ejector is of special construction, and forms a very important portion of the apparatus, as it is necessary that any steam leaking past this valve shall not be permitted to reach the sand, and make it damp, as this would interfere with the proper working of the apparatus. To prevent this, a valve of the plug type is made use of, in which the steam is admitted to the center of the plug, passing out by the side opening when the ejector is at work. At all points where leakage may occur grooves are cut to intercept the water, and these are connected with a drip-pipe which discharges into a warm spot below the footplate, so that there is but little chance of the pipe getting blocked by frost.

This apparatus seems capable of doing good service, and would be worth a thorough trial on locomotives. An excellent report of it is made on several English roads.

LOCOMOTIVE PRACTICE.

(From the London *Engineering*.)

"WHY," says the railway passenger when he finds himself seated opposite to an engineer, "why do I see the express locomotives on some lines with outside cylinders, while on other lines they have inside cylinders?" "Why are coupled driving-wheels used by one company and not by another?" "Why have some locomotives domes while some have not?" And so he goes on with his eternal string of questions, to which satisfactory answers are so difficult to find. Of course it is easy to point out that every line has its peculiar features, which are best met by a certain type of engine, and that the present forms have been arrived at by a long course of trial and error. But when every allowance has been made for local peculiarities, there still remains an amount of dissimilarity which is not satisfactorily explained. If the railways were undertaken by the State, and one of the present well-known locomotive superintendents had all the engines placed under his charge, it is certain that, apart from any question of economy of construction and repair, many of the leading types of locomotives would disappear. He would mentally dismiss them at once as coming short of his conception of the best practice, and as opportunity occurred he would break up or remodel them. We have only to assume the post to be given to any one of our leading locomotive engineers to be able to predict which of the many existing patterns of engines would survive or which would be shelved. The personal element would turn the scale, even as one has to confess to the inquisitive passenger it does now. What a great influence it exerts has recently been brought out very clearly by a report addressed by Mr. C. Rous Marten to the Minister of Public Works in New Zealand. Mr. Marten spent many months studying our railways, visiting all those of any importance, and making repeated trips on the most important trains, often on the footplate of the locomotive. He met the managers and engineers of most of our principal lines, and gathered up information of all kinds in a way which shows how great an interest he took in the subject. The locomotive had a special attraction for him, and in a few pages he sketched the principal types in use for heavy express traffic, pointing out how wide are the differences of practice on lines which are not greatly dissimilar in character. Most of the engines to which he alludes have already been illustrated in our columns, but as the locomotive has a fascination for many people who lay no claim to a critical knowledge of it, it will probably be of interest if we follow Mr. Marten in his round of inquiry, and note the differences which he found. In the boilers of engines used for working the fast main line trains the heating surface varies from 1,000 square feet to 1,500 square feet, the following being the areas adopted in the chief classes of express engines: Great Western, 1,278;



STEAM SANDING APPARATUS FOR LOCOMOTIVES.

London & Southwestern, 1,216; London, Brighton & South Coast, 1,284 and 1,485; Great Eastern, 1,200; Great Northern, 1,021 and 1,165; London & Northwestern, 1,074 and 1,450; Midland, 1,121 and 1,313; Manchester, Sheffield & Lincolnshire, 1,144; Northeastern, 1,208; and Caledonian, 1,208 square feet. As regards position of cylinders, the tendency of late has been toward the almost exclusive use of inside cylinders, the most notable exception being the London & Southwestern Railway, which uses outside cylinders for all its passenger engines. There is an exceedingly fine and efficient class of outside cylinder express engines on the Great Northern Railway, but Mr. Stirling is now also building engines with the inside cylinder arrangement.

The greatest diversity of opinion is found on the bogie question. The Great Western, the London & Northwestern, and the London, Brighton & South Coast reject the bogie altogether, even for the tank engines, the London & Northwestern substituting radial axle-boxes. The Great Northern uses the bogie for one class of express engines only, but employs it freely on tank engines. The Great Eastern has a large number of bogie locomotives running, both tank and main line engines, but is dispensing with bogies on new express engines, save on the compounds. The Midland uses it for all tank engines, but of the new express engines there are more without it than with it. The London & Southwestern uses it on all new passenger engines. So does the Southeastern since Mr. J. Stirling took charge, and the London, Chatham & Dover, since Mr. Kirtley came. The Manchester, Sheffield & Lincolnshire Railway uses it with the coupled engines, but not with the singles, thus reversing the Great Northern practice. The Northeastern did not use it on express engines at the date of Mr. Marten's visit, but Mr. Worsdell has built some fine compound express engines with bogies since. The North British and the Caledonian now build all passenger engines with bogies.

Another point on which the practice of locomotive engineers is curiously divergent is the use of domes, but it is not worth while to give a detailed list of the companies which use them, and of those which do not. A more important matter is the comparative advantage and disadvantage of single and coupled wheels for engines working express traffic. A few years ago opinion set strongly in favor of the latter, and with the exception of the Great Northern no railway was building single engines. Then a reaction set in; Mr. Stroudley, on the London, Brighton & South Coast line, brought out the *Imberhorne* class, with 6 ft. 6 in. single wheels; Mr. Sacré, on the Manchester, Sheffield & Lincolnshire Railway, the fine 7 ft. 6 in. singles of the "399" class; Mr. Bromley, on the Great Eastern, the 7 ft. 6 in. singles of the "245" class. Mr. Stirling, on the Great Northern, built a number more of 8 ft. singles, and more recently introduced the 7 ft. 6 in. singles with inside cylinders. A fresh type of single-wheel engine has been turned out by Mr. Drummond on the Caledonian, with 7 ft. 2 in. single driving-wheels, and a sand blast to improve adhesion. Engines similarly fitted are being used on the Midland with excellent results.

Many of these differences are very difficult to explain by reference to the peculiarities of the roads or of the traffic. The lines which use single engines are not the freest from heavy gradients, and those which use bogies have not the sharpest curves. The heaviest trains are not drawn by the engines with the greatest heating surface. The personal opinions of the locomotive superintendent, and the fashion of the hour, exercise an immense influence, which is no doubt increased in some cases by want of opportunity for making comparisons. It is seldom that two different classes of engines do exactly the same work, and consequently it is impossible to compare their performances with precision. There are so many allowances to be made for factors which are not identical in the two problems, that the result depends largely upon the judgment of the man making the calculation. It is only when an engine is pressed to its utmost that the effect of special features in its design and proportions really make themselves apparent. Fast light trains could be run as well 30 years ago as to-day, and slow heavy trains were nearly equally well handled. It is the combination of high speed and great weights which is so trying to the locomotive engineer of to-day. When the engine is pressed to the limits of its capacity, every peculiarity of the road is felt, and a design must be got out which will give the best average result over the run. Mr. Marten's footplate experiences show us with what difficulty the present speeds are maintained. He seems to have made very minute inquiries and observations, and he records that on three occasions only, all of a somewhat special character, did he register a speed of 76.28 miles an hour, with light loads, down gradients of 1 in 89 to 1 in 200; once with a Great Western 8 ft. single, once with a Great Northern 8 ft. single; and once with a Midland 7 ft. coupled having 19-in. cylinders. In each case the engine was pressed to its utmost capacity. With Midland engines having 6 ft. 8 in. wheels he recorded 75 miles an hour; with London & Northwestern and Caledonian 6 ft. 6 in. engines, 74 miles an hour was reached down the Shap and Beattock banks respectively. With a London & Northwestern engine with 5 ft. 6 in. wheels, nearly 72 miles was attained down the former bank, and 60 miles per hour with a 4 ft. 6 in. tank engine on the same railway. The highest speed ever known to have been attained in this country is recorded of the ten-wheeled tank engines with 9 ft. single driving-wheels, built for the Bristol & Exeter line in 1852, which actually touched 80 miles an hour, with no load, down a gradient of 1 in 89, and 78 miles an hour with vehicles. One of these engines ran 70 miles an hour on the level with two coaches. Where this is the best that can be done under most favorable circumstances, it will be readily understood that the ordinary heavy express runs up to the very limit of its capacity, and that down hill it has to make a speed of 70 to 75 miles an hour to keep time. Mr. Marten records three splendid runs at which a sustained speed of about 60 miles an hour was kept up; with the Great Northern's Manchester express between London and Grantham he twice covered 100 miles in 103 minutes, and on the Great Western between Swindon and London 72 miles in 71 minutes, the engine in each case being an 8-ft. single driver. With a Midland 7-ft. coupled engine, having 19-in. cylinders, he travelled 58 miles an hour, and the same was done in a train drawn by a London & Northwestern *Precedent*. Although these are somewhat exceptional examples, yet there are in summer no fewer than 105 runs timed to be made daily, from start to stop, at an average speed of 50 miles an hour and upward. The highest average speed at which a train is timed from start to stop is just 54 miles an hour. This is the Great Northern's Manchester up express, which performs the longest run in the world without stop—105 miles, 26 chains, to be done in 1 hour and 27 minutes. The Great Western's Exeter expresses stand third with 53¼ miles an hour. Over the first 77 miles out of London two down trains and one up train are timed at this speed. The Great Northern has no fewer than seven trains, and the Great Western three, timed at an average running speed of over 53 miles an hour between stopping stations. Besides these there are in the country 25 trains at 52 to 53 miles an hour, 27 at 51 to 52, and 40 at 50 to 51 miles an hour running time. It is no wonder, in the face of these speeds, that locomotive engineers are feeling in all directions to get engines of greater power. Mr. Webb is going in bodily for the compound system, and appears to be getting splendid results out of it. Mr. Worsdell is also adopting the compound system—worked out on another way—very freely, while others are waiting to see the results. On our great competing lines we have come to the limits of the capacity of the ordinary locomotive, whatever the form it takes, and if trains are to be increased in weight, or speed to be materially augmented, some new departure must be made.

A Proposed California Bridge.—The Southern Pacific Company is now having surveys made to ascertain whether it will be practicable to build a bridge across the Strait of Carquinez, to take the place of the steam ferry by which trains are now transferred there. In order to avoid, as much as possible, interruption to navigation, it is proposed to make a bridge 100 ft. at least above high-water mark. Its entire length will be between 3,500 and 4,000 ft.; the depth of water varies from 55 to 180 ft., but the bottom is generally rock, so that it is not thought there will be much difficulty in finding foundation for the piers. No decision as to the building of the bridge will be reached until the surveys are completed.

CATECHISM OF THE LOCOMOTIVE.

(Revised and enlarged.)

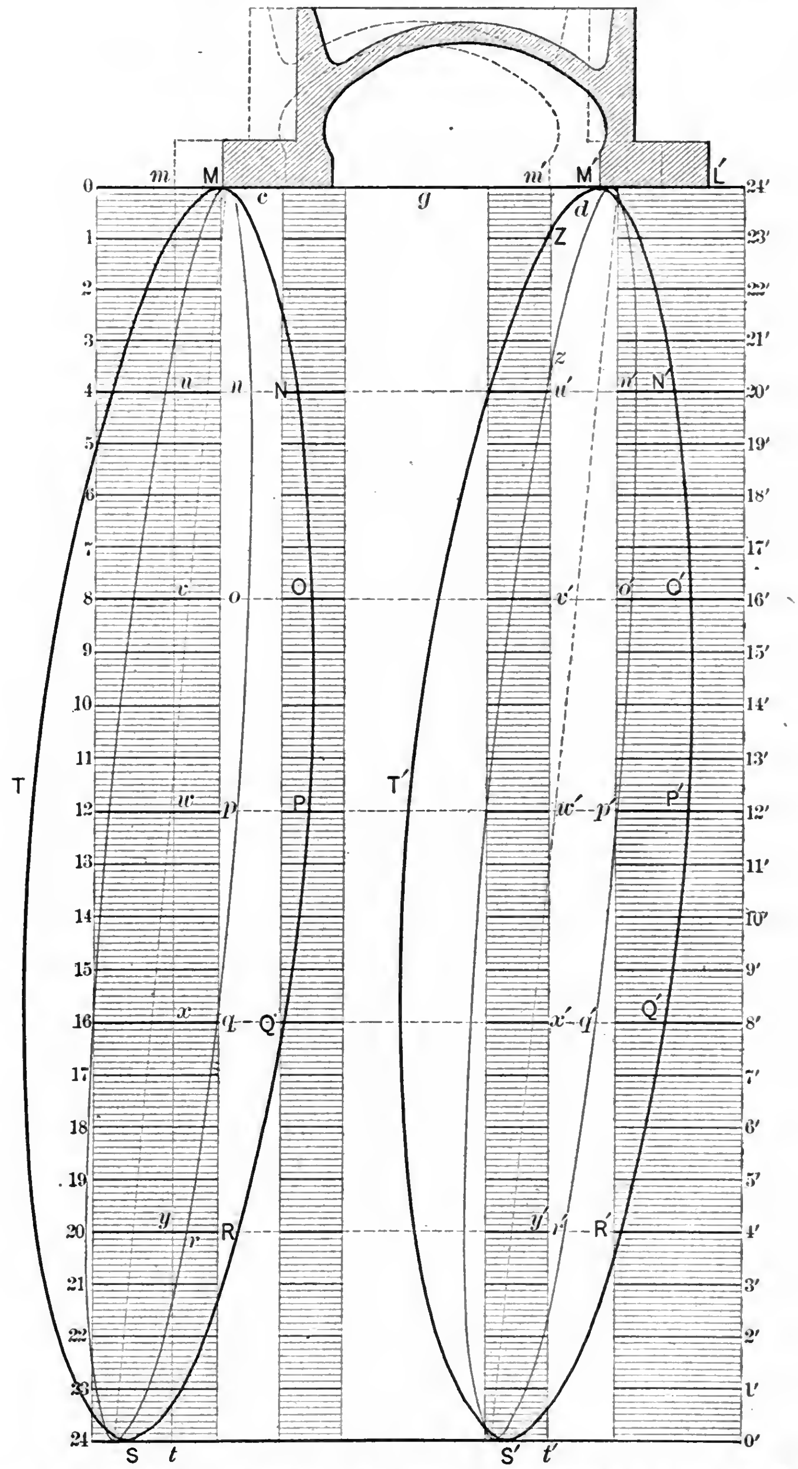
By M. N. Forney.

(Continued from page 326.)

CHAPTER XIII.—*(Continued.)*

THE VALVE GEAR.

Question 340. *Can the position of each edge of the valve, with any given amount of travel, be shown in its relation to the ports by one motion-curve, or is it necessary to draw such curves for each edge of the valve?*



Answer. One motion-curve is sufficient to represent the movement of any part of the valve in relation to the ports during its entire travel. This will be apparent if it is remembered that the movement of any portion of the valve is exactly the same as that of every other part, and therefore the curve which represents the motion of one part is exactly like that which represents the movement of any other part. This is shown in fig. 218, in which the two sets of curves, below *M* and *M'*, are exactly alike. Therefore, all that is needed to show the movement of any part of the valve in relation to the ports is to draw lines to represent the ports in their relative positions to the valve. In this way one curve can be made to show the movement of all the parts of the valve in relation to the ports below it. To illustrate this, it will be assumed that a motion-curve, *M N O P Q R S T*, fig. 223, which represents the maximum travel of a valve, has been drawn with the instrument described in answer to the previous question. When this curve has been drawn it will be supposed further that the crank-pin has been placed on the forward dead-center, and the shaft *F*, fig. 222, has been fastened by a nut provided for that purpose in the position it then occupies, and that the connecting-rod *H* is detached from the arm *G*, and by a stroke of the piston the pencil *P* has drawn a straight line, *M s*, fig. 223. This line will represent the position of any part of the valve when the crank is on the front center, and the curve will represent the movement

and position of the same part during one revolution of the crank-pin. It will be supposed that the line $M\ s$ represents the position of the steam-edge M, fig. 218, of the valve at the beginning of the stroke. Usually, when a valve worked by a link motion has its greatest travel, it has no lead at the beginning of its stroke, but its edge conforms to that of the steam-port, or, as it is expressed, it is set "*line-and-line*" with the port. If that is the case the line $M\ s$, fig. 223, will represent the edge of the steam-port. If the valve has lead, then a line drawn parallel to $M\ s$, at a distance from it equal to the lead, will represent the edge of the port. In fig. 224 the valve is shown with $\frac{1}{16}$ in. lead, and another line, $a\ b$, has been drawn at a distance from $M\ s$ equal to the width of the port c, fig. 218. The curves $M\ N\ O\ P\ Q\ R\ S$ and $M\ n\ o\ p\ q\ r\ S$ then represent the motion to $M\ s$, and assume that M, fig. 224, represents the exhaust-edge of the valve, then the relation of the two curves to the lines $m'\ t'$ and $h\ i$ will represent the motion of the valve in fig. 224 in the same way as it is shown by the curves $M'\ N'\ O'\ P'\ Q'\ R'\ S'$ and $M'\ n'\ o'\ p'\ q'\ r'\ S'$ in fig. 218. Thus the one set of curves will represent the motion of the valve in relation to both of the steam-ports during the backward stroke of the piston. It remains to show its motion during the forward stroke.

It will be understood that if a line, $K\ S'$, fig. 223, is drawn when the crank-pin is on a dead center and the piston at the back end of the stroke, that it will represent the position of the edge of the valve when the piston is in that position or is at the beginning of the forward stroke, just as $M\ s$ represented it at the beginning of the backward stroke. A vertical line, L', is there

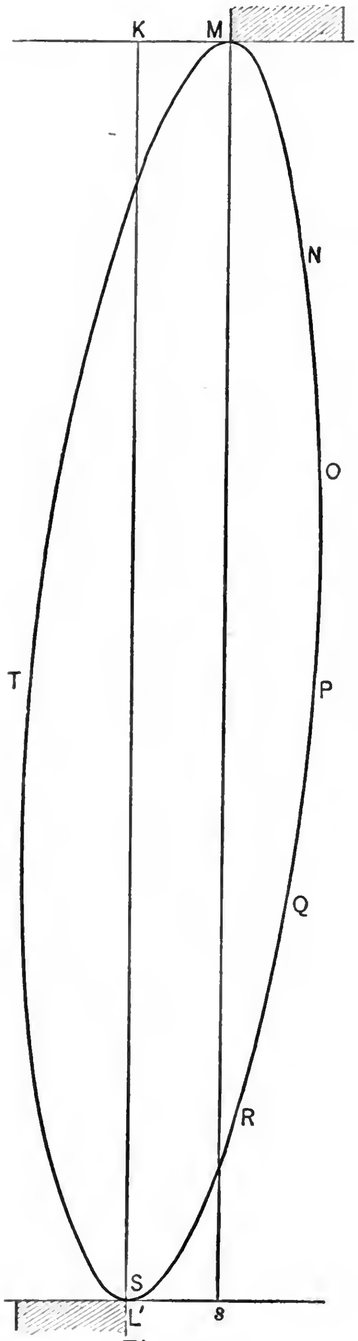


Fig. 223.

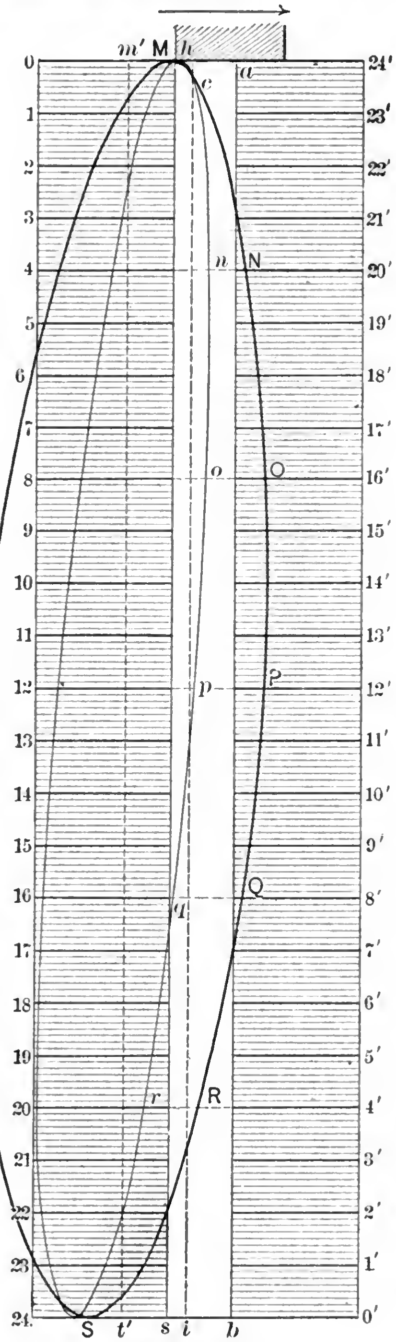


Fig. 224.

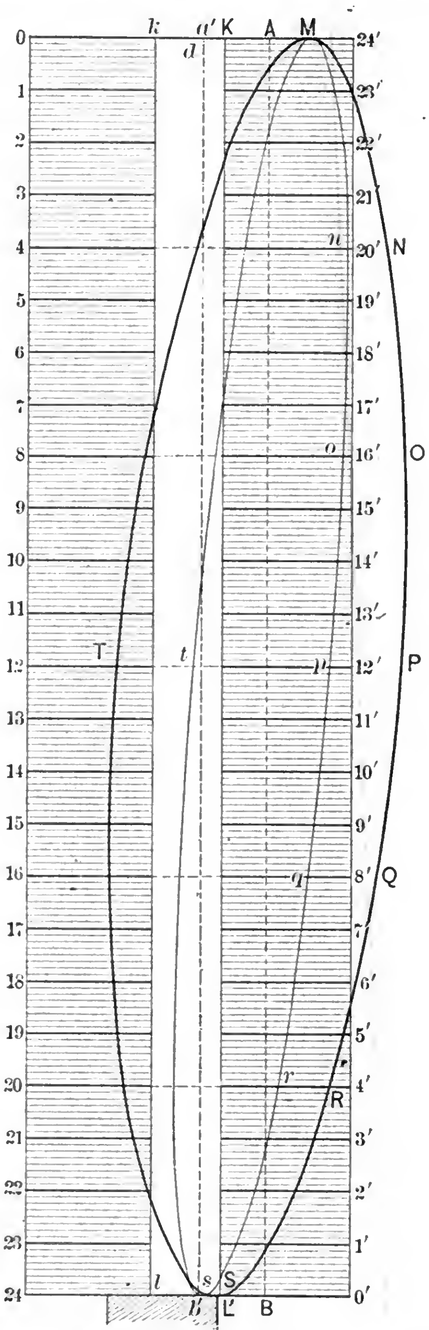


Fig. 225.

of the valve in relation to the port c in the same way as it is shown in fig. 218.

It has already been explained, that the movement of the edges M and M' of the valve, and the two sets of curves in fig. 218, are exactly alike. They differ from each other only in their relation to the ports c and d. The steam-edge, M, it will be seen, is $\frac{1}{16}$ of an inch—equal to the lead—from the line $M\ s$ or the edge of the port c, whereas the exhaust-edge M' is 1 in. from $m'\ t'$, the inner edge of the port d. If, then, in fig. 224, we draw a line $m'\ t'$, 1 in. from M, and another, $h\ i$, at a distance from $m'\ t'$ equal to the width of the port d, fig. 218, and parallel fore drawn below the horizontal line $L'\ s$ to represent the steam-edge L', fig. 218, of the valve. In fig. 225 the line L' has been laid down in the same position as in fig. 223, but the line $K\ L'$ has been drawn $\frac{1}{16}$ of an inch from L', to represent the lead of the valve, and another line, $k\ l$, is drawn parallel to it at a distance equal to the width of the port d, fig. 218. If this is done the relation of the curves $S\ T\ M$, and $s\ t\ M$ in fig. 225, will represent the movement of the steam-edge L', fig. 218, of the valve in relation to the port d, just as the movement of M is shown in fig. 224.

To show the motion of the exhaust-edge L in relation to the

port c, fig. 218, a line, $A\ B$, is drawn in fig. 225 1 in. from L', or in the same relative position to L' that $m'\ t'$ occupies to M' in fig. 218. Another dotted line, $a'\ b'$, is drawn in fig. 225 at a distance from $A\ B$ equal to the width of the port c. The relation of the curves $S\ T\ M$ and $s\ t\ M$ to these dotted lines will show the motion of the exhaust-edge L of the valve to the port c, fig. 218, just as that of M' was shown in fig. 224. It will require no explanation to show that the two diagrams, figs. 224 and 225, can be combined in one, as shown in fig. 226, and in that way the movement of the valve in relation to each of the steam and of the exhaust-port may be shown during a complete revolution of the crank by one set of motion-curves.

then it will be in the same relation to the port indicated by the dotted lines $m'\ t'$ and $h\ i$ that it has to d in fig. 218.

Diagrams of this kind, which are made full size, will, of course, show the movement of the valve more distinctly than is possible in the space occupied by the illustrations herewith. When they are made full size, the lines indicating the ports should be drawn of different colors, so as to distinguish them from each other easily. Such diagrams will show the position of the valve in relation to the ports and indicate the distribution of the steam during the whole stroke. It is only necessary to refer the curve to the proper line to determine the position of the valve in relation to either of the ports for either the admission or

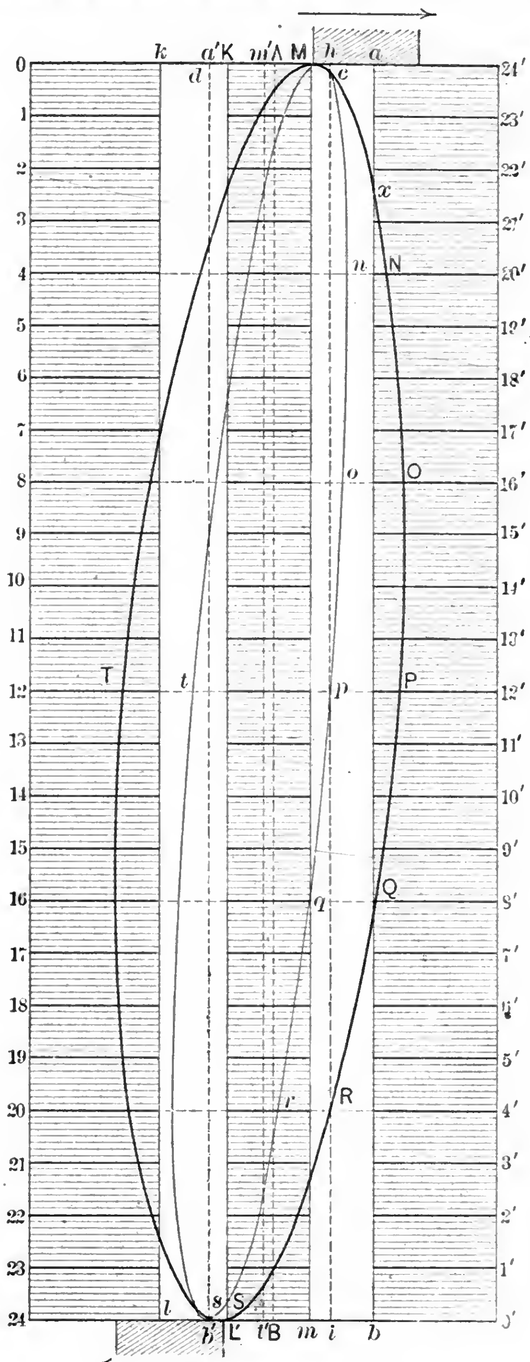


Fig. 226.

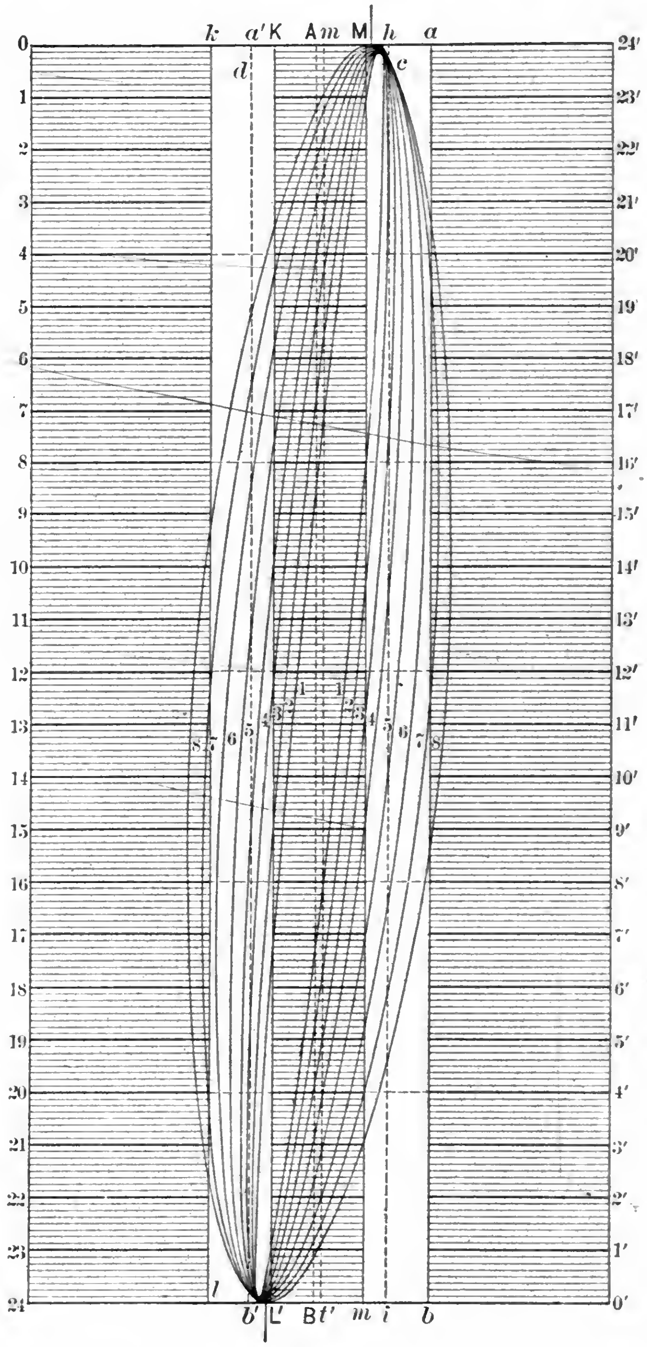


Fig. 227.

It will be seen that in a diagram like fig. 226 the relative position of the ports c and d is reversed from that in which they actually are, as shown in fig. 218. If desirable, the inner edges of the exhaust-port g could also be laid down on the diagram, so that the motion of the valve with reference to them would be shown.

If the reader will cut a paper section of a valve, like that shown in fig. 51, and place the different edges, a, f, and b, so that they will successively correspond with the line M in fig. 226, the diagram will, perhaps, be more clear. If, for example, the paper section be placed to the right of the line M, so that its edge a will correspond with M, then it will be seen that the port c occupies the same relation to it that it does in fig. 218. If the valve be placed so that the edge b corresponds with M,

release of the steam. If, for example, we want to observe how the admission of steam is governed by the valve, by referring to fig. 226 we see that at the beginning of the backward stroke the valve has $\frac{1}{16}$ in. lead; that at $2\frac{1}{2}$ in. of the stroke the port c is wide open, as shown by the intersection of the motion-curve with the line $a\ b$ at x; that the valve has received its maximum backward travel at 9 in. of the stroke, and begins to close the port at $16\frac{1}{4}$ in., and completely closes it at $21\frac{1}{2}$ in. of the stroke. By referring the motion-curve to the lines $K'\ L'$ and $k\ l$, we see that the valve as shown, L', again has $\frac{1}{16}$ in. lead at the beginning of the forward stroke; that the steam-port is wide open at $1\frac{3}{4}$ in. of the stroke; begins to close at $16\frac{3}{4}$ in., and is completely closed at $21\frac{1}{2}$ in. By referring the curve to the lines $m'\ t'$ and $h\ i$, we see that the front port begins to open to the ex-

haust before the piston has completed its forward stroke, that it is wide open almost immediately after the piston begins its stroke, does not begin to close until the piston has moved 20 in. of its stroke, and is completely closed at 23¼ in. of the stroke. By referring the curve to the lines a' b' and A B, almost the same phenomena will be observed for the forward stroke of the piston. In fact, from such a diagram the whole motion of the valve can be studied and analyzed with the greatest accuracy; and, as has already been shown, the motion imparted to a slide-valve by a link is of so complicated a nature that it is almost or quite impossible to observe its exact nature without diagrams of some kind.

QUESTION 341. *Can a diagram be constructed to represent the motion of the valve with different amounts of travel?*

Answer. Yes. In figs. 224, 225, and 226, two motion-curves are shown, one in heavy and the other in light lines. It is only necessary to construct motion-curves for the same diagram for each distance traveled, and they will show the movement of the valve for the given amount of travel represented by the curves. Fig. 227 is a reduced copy of a series of motion-curves taken from a locomotive. From this diagram the movement of a slide-valve worked by the link-motion can be seen from the highest to the lowest practicable point of cut-off. For convenience of reference the curves have been numbered.

The smallest travel of the valve represented by curve No. 1 is a little less than 2½ in., and the ports are then opened only about ⅜ in., and the steam is cut off at 8 in. on the backward and 6¾ in. on the forward stroke. The exhaust is opened or the steam is released during the backward stroke at 17¼ in., and during the forward stroke at 16⅝. When the valve works with its greatest travel, as represented by curve 8, it travels 5 in., and opens the steam-port wide at 3½ in. of the backward stroke and 2¼ in. of the forward stroke. The steam is cut off at 20⅝ and 20½ in., and its release takes place at 23⅛ in. of each stroke. The following table gives the greatest width of opening, the point of cut-off, the point of release, and the lead for such a series of motion-curves. This table was made up from the motion-curves drawn with an instrument like that described in answer to Question 339, on a locomotive which had been running about eighteen months and whose valve-gear, consequently, was considerably worn, as was indicated by the flatness of the motion-curves on each side at the point when the motion of the valve was reversed. This flatness was caused by the lost

No. of curve.	Travel of valve.	Width of opening of steam-port.		Point of cut-off.		Point of release.		Lead.
		Backward stroke.	Forward stroke.	Backward stroke.	Forward stroke.	Backward stroke.	Forward stroke.	
	in.	in.	in.	in.	in.	in.	in.	in.
1	2½	11/32	5/16	8	6¾	17	16⅝	9/32
2	2⅝	7/16	13/32	9½	9½	18⅝	18 5/16	¼
3	2⅞	9/16	½	12	11¾	19¾	19 9/16	7/32
4	3⅛	11/16	41/64	14	14	20 11/16	20 9/16	3/16
5	3½	⅞	27/32	16½	16½	21 11/16	21½	5/32
6	4	1⅛	1 3/32	18¼	18⅛	22⅜	22¼	⅛
7	4½	1¼	1¼	19⅝	19½	22 13/16	22¾	3/32
8	5	1¼	1¼	20⅝	20½	23⅛	23⅛	1/16

motion in the valve-gear, the pencil remaining for a time stationary when the motion was reversed and while the parts were moving from their bearings on one side to those on the other. The curves and the table, therefore, show the operation not of a theoretically perfect valve-gear, but are examples of actual practice, with such imperfections as are incidental to ordinary locomotives. It will be seen that the instrument shows not only what the valve-gear should, but what it actually does do, and delineates all its imperfections.

QUESTION 342. *What are the chief dimensions of the valve-gear whose motion is represented in fig. 227?*

Answer. The throw of eccentrics was 5 in., the steam-ports were 1¼ in., and the exhaust-port 2⅝ in. wide, the valve had ⅞ in. outside and 1/16 inside lap and 1/16 in. lead at full stroke.

QUESTION 343. *What relation is there between the distance which the ports are opened by the valve and its travel when worked by a link?*

Answer. As explained in the answer to Question 121, the width which the steam-ports are opened by the valve for the admission of steam diminishes with the travel of the valve. This is shown very clearly by the motion-curves and also in the above table, from both of which it will be seen that when the valve travels only 2½ in. the steam-ports are opened only 11/32 in. for the back stroke and 5/16 for the front. With 2⅝ travel the opening is 7/16 and 13/32 in. With 4 in. travel the port is opened 1⅛ and 1 3/32 in., and with 4½ in. travel they would be opened wide. With 4½ and 5 in. travel, as will be seen from the motion diagram, the ports are not only opened wide, but the valve throws "over" them, or travels beyond their inner edges.

QUESTION 344. *How is the point of cut-off affected by the link?*

Answer. Changing the travel of a valve with a link has a very similar effect to that produced by eccentrics of different throw—that is, the period of admission is increased with the throw of the eccentric and that for expansion lessened. This is shown clearly in both the motion diagram and the table. With the first curve and a travel of 2½ in. the steam is cut off at 8 in. for the backward stroke and 6¾ in. for the front, and with 5 in. travel steam is admitted during 20⅝ in. of the backward and 20½ in. of the forward stroke.

QUESTION 345. *How is the point of release or exhaust of the steam affected by the link?*

Answer. As the travel increases, it is delayed until later in the stroke. Thus, with 2½ in. travel the steam is exhausted or released from the cylinder during the backward stroke when

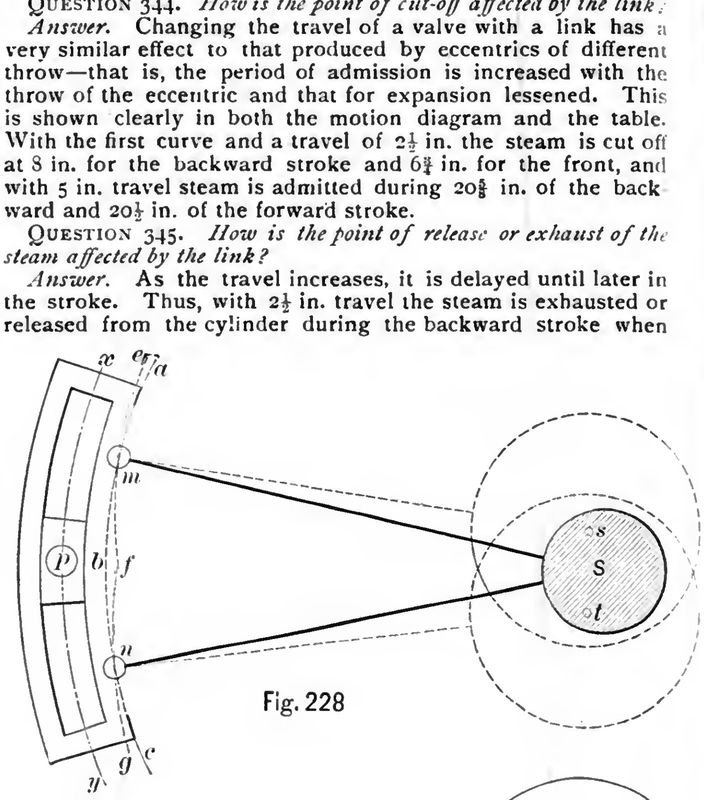


Fig. 228

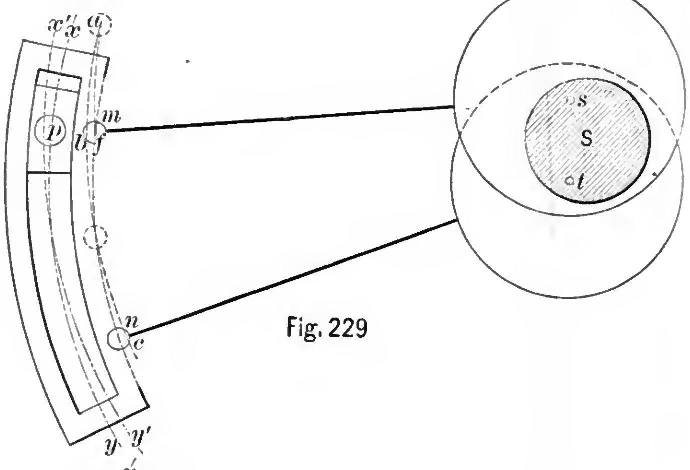


Fig. 229

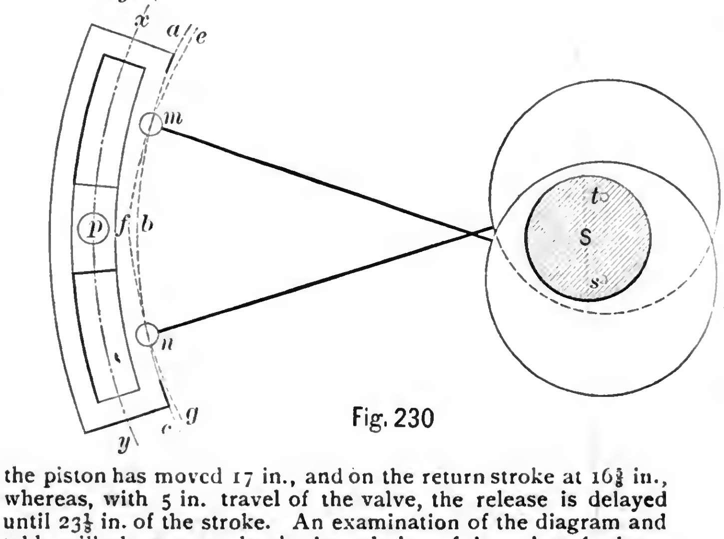


Fig. 230

the piston has moved 17 in., and on the return stroke at 16⅝ in., whereas, with 5 in. travel of the valve, the release is delayed until 23⅛ in. of the stroke. An examination of the diagram and table will show very clearly the relation of the point of release to the travel.

QUESTION 346. *How is the lead affected by the ordinary link-motion?*

Answer. It is increased as the travel is diminished, as is

shown in the table, and also by the inclination of the curves at the top and bottom of the diagram.

QUESTION 347. *What is the cause of this change of the amount of lead?*

Answer. This can be best explained by reference to fig. 229, which represents a link with very short eccentric rods. If the center from which the link was drawn was in the center of the axle *S*, and the eccentric straps embraced the axle instead of the eccentrics, their ends *m* and *n*, from *S* as a center, would each describe the same arc, *a b c* parallel with the center line, *x s*, of the link, and the latter could then obviously be raised and lowered without moving the block *b* or rocker-pin *p* at all. But the eccentric straps being attached to the eccentrics, as shown by the dotted lines, when the rods are raised or lowered they describe arcs *e f* and *f g*, from the centers *s* and *t* of the eccentrics, and not from the center of the axle. When the link is lowered, then, the end *m* of the upper rod obviously moves in the arc *m f*, and the top of the link is moved toward the axle, a distance equal to *b f*, as shown in fig. 230, equal to the interval between the arc *a b c*, drawn from the center of the axle, and *e f*, which the rod *m s* describes from the center of its eccentric. When the link is raised from mid-gear, fig. 229, to back-gear, a similar action takes place, as the end *n* of the lower rod then describes an arc, *n f*, so that the whole link is again thrown toward the axle a distance, *b f*, equal to the space between the arcs described from the center of the axle and the centres of the eccentrics. When the position of the eccentrics is reversed, as shown in fig. 231, the link is moved from the axle, thus causing an increase of lead on the opposite side of the valve. We have employed for our illustrations very short eccentric rods, in order to make this action apparent by exaggerating it. It is obvious from the engravings that the difference in the lead is increased as the eccentric rods are shortened, and also as the distance between the points of connection of the rods with the link is increased. It will also be plain that increasing the throw of the eccentrics—that is, increasing the distance of the centers *s*, *t*, of the eccentrics from the center *S* of the axle will also increase the variation in the lead in full and mid-gear.

QUESTION 348. *What is meant by the distribution of steam in the cylinder?*

Answer. It means the admission and exhaust of steam to and from the cylinder in relation to the stroke of the piston or the revolution of the crank.

QUESTION 349. *What are the principal periods or elements of the distribution of steam by the slide-valve and link-motion?*

Answer. They are:

1. The *pre-admission* or lead—that is, the admission of steam into the cylinders in front of the piston before it has completed its stroke.
2. The *admission* of steam after the piston has commenced its stroke.
3. The *expansion* of steam in the cylinder.
4. The *pre-release* or exhaust of steam before the piston has completed its stroke.
5. The *release*, or exhaust during the return stroke of the piston.
6. The *compression* of steam or closing the exhaust before the piston has completed its return stroke.

QUESTION 350. *What is meant by the clearance of the piston?*

Answer. It is the space between the piston and the cylinder-head when the former is at the end of its stroke. If the piston touched the cylinder-head at the end of each stroke, it would cause a concussion or "thump," which would injure these parts. Owing to the impossibility of constructing machinery with absolute accuracy, it is therefore necessary to leave a space, usually from ½ to ¼ in. wide, between the piston and the cylinder-heads, so as to be certain that they will not strike each other should there be any slight inaccuracies in the length of the piston-rods, connecting-rods, frames, or other parts.

QUESTION 351. *Why is it desirable to open the steam-port and admit steam at the end of the cylinder toward which the piston is moving BEFORE the latter has completed its stroke?*

Answer. Because it is essential, in order to insure a good action of the steam, that the maximum cylinder pressure should be attained at the very commencement of the stroke. If the steam-port was not opened until after the piston had commenced its stroke, some appreciable time would be consumed in filling the clearance space and the *steam-way* with steam.* It is also found, especially if an engine is working at a high speed, that a slide-valve worked by the ordinary link-motion will not open the steam-port rapidly enough to enable steam of the maximum boiler pressure to fill the space after the receding piston, unless the valve begins to open the port *before* the piston reaches the end of its stroke.

Another advantage resulting from the pre-admission of steam consists in the smooth working of the engine at high speeds, a circumstance which reduces greatly the wear and tear of the working gear. As the piston approaches the end of its stroke, the pre-admitted steam forms a kind of elastic cushion, which is well calculated to absorb the momentum of the reciprocating parts at that instant. The pressure due to the momentum of these parts will, of course, depend upon their weight and the speed of working, increasing directly as the square of the speed. It follows from this that the lead should increase with the speed, and that it should be greatest at high speeds. As has been shown before, this condition is fully accomplished by the ordinary shifting-link motion.

QUESTION 352. *Upon what does the admission of steam into the cylinder depend?*

Answer. It depends in the first place upon the opening of the throttle-valve, and the size of the pipes and passages through which it is conveyed from the boiler to the cylinder. In the second place, it depends upon the time and amount of opening of the steam-port by the valve.

QUESTION 353. *What should be the pressure of the steam in the cylinder during admission?*

Answer. In order that the steam may be used to most advantage, it should be admitted and maintained in the cylinder as near full boiler pressure as possible during the whole period of admission. If the opening of either the throttle-valve or the steam-ports is not sufficient to allow the steam to flow into the cylinder at full boiler pressure, the steam is said to be wire-drawn, and some of the advantage of using it expansively, as has already been explained in answer to Question 92, is then lost.

QUESTION 354. *Why is it difficult to admit and maintain steam at the full boiler pressure in the cylinder during admission?*

Answer. Because it is necessary to reduce the travel of the slide-valve in order to cut off the steam "*short*," or soon after the beginning of the stroke of the piston. When the travel is reduced, the valve opens the port only a small distance, so that the area of the opening is not then sufficient to allow the steam to flow into the cylinder with sufficient rapidity to fill it at full boiler pressure, especially if the engine is working at a high speed. Thus, by referring to the table given on page 368 and to the motion-curves in fig. 227, it will be seen that when the steam is cut off at from ¼ to ½ stroke, the port is opened for the admission of steam only from ¼ to ½ in. wide. From the curves it will also be seen that the valve then acquires its maximum travel and the steam-port its greatest width of opening very soon after the piston begins its stroke; after which the port is gradually closed, so that before the steam is entirely cut off the opening is so much reduced in area that the steam cannot flow through it rapidly enough to maintain the steam at full boiler pressure in the cylinder when the engine is working at high speeds.

QUESTION 355. *What means are used to overcome this difficulty and thus admit steam at fuller boiler pressure when the valve is cutting off short?*

Answer. In the first place, the steam-ports are made from ten to twelve times as long as they are wide, so that a narrow opening will have a comparatively large area. In the second place, by giving the valve lead, not only are the clearance space and the steam-way filled with steam when the piston begins its stroke, but the port is then open a distance equal to the lead. With the ordinary link-motion, as has already been shown, this lead increases as the travel and period of admission diminish, so that the smaller the total distance that the port is opened, the greater is its opening at the beginning of the stroke. As the steam is usually cut off short when locomotives run at high speeds, it will be seen that the increased lead which is imparted to the valve by the shifting link is an advantage rather than a disadvantage. But while it is often possible in this way to secure a pressure of steam in the cylinder at the beginning of the stroke equal or nearly so to that in the boiler, yet it is almost impossible to maintain this pressure during the whole period of admission, when the steam is cut off short and the engine working at a high speed. To obviate this evil what is called the Allen valve was designed, which is represented in fig. 231. This valve has a channel or supplementary port, *a a*, which passes over the exhaust cavity, and has two openings, *b b'*, in the valve-face. When the valve begins to admit or "*take*" steam at *f*, as shown in fig. 232, it will be seen that it also uncovers the opening *b'* at *e* and thus admits steam at *e'*, which passes through the channel *a a* and enters the steam-port *c* at *b*, and in this way there is a double opening for the admission of steam. The opening *b* of the supplementary port is closed as the valve advances, but when this takes place the steam-port is uncovered far enough at *f* to admit all the steam that is required. This form of valve is very efficient when the travel

* The steam-ways are the passages which lead from the steam-chest to the cylinder, and are sometimes called steam-ports, but the term steam-ways is used to distinguish the passages from their openings in the valve-seat, which latter are more properly called steam-ports.

and point of cut-off are very short. It then gives just twice as much opening as the ordinary valve for the admission of steam.

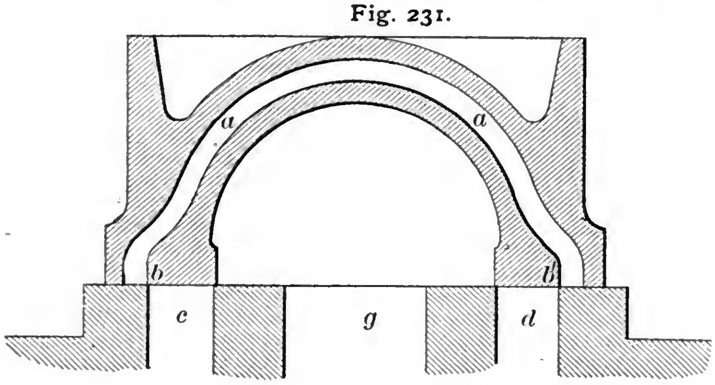
QUESTION 356. *What is meant by the pre-release of steam ?*

Answer. It is the release of the steam before the piston has completed its stroke. If the steam was confined in the cylinder until the piston had reached the end of its stroke, there would not be time, nor will it be possible, with a slide-valve and link-motion, to secure a sufficiently large opening of the port to permit the steam to escape from the cylinder before the piston begins its return stroke. If there were no pre-release, there would therefore be more or less back pressure on the piston.

QUESTION 357. *Upon what does the amount of pre-release depend ?*

Answer. First, as has already been explained in answer to Question 125, on the amount of inside lap ; and, second, on the outside lap of the valve and lead of the eccentrics ; and, third, on the travel of the valve. The less the inside lap, the greater the outside lap and consequent lead of the eccentrics, and the shorter the travel of the valve, the earlier will be the release. The proper amount of this pre-release depends upon the velocity of the piston and the quantity of steam to be discharged or the degree of expansion. From the motion-curves in fig. 227 it will be seen that it is a marked feature of the shifting-link mo-

Fig. 231.



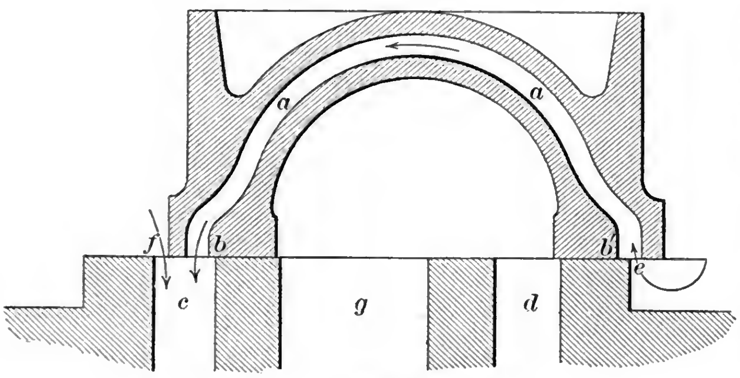


Fig. 232.

tion that the pre-release occurs earlier in the stroke as the link approaches mid-gear, or as the travel of the valve diminishes. As the link is usually worked near that position when the engine is run at a high speed, it will be seen that in this respect again the link-motion is well adapted for working the slide-valves of locomotives.

QUESTION 358. *What governs the period of release ?*

Answer. The release, like pre-release, is dependent upon the amount of inside lap, the outside lap and consequent lead of the eccentrics, and the travel of the valve. The addition of inside lap has the effect of closing the port earlier than it would be closed without, and thus shortening the period of release and also of reducing the area of the opening of the port.

With the same travel, increase of outside lap and lead shortens the period of release, but has no effect on the width of the opening of the port to the exhaust.

Increase of travel, with the same outside lap, lengthens the period of release and also increases the width of the opening of the port to the exhaust.

QUESTION 359. *What governs the period of compression ?*

Answer. As compression begins when release ends, or when the port is closed to the exhaust, it is controlled by exactly the same causes, and as the two events occur simultaneously, of course whatever shortens the period of release lengthens that of compression.

QUESTION 360. *What effect do the clearance spaces and steam-ways have upon the compression of the confined steam ?*

Answer. By referring to the motion-curves in fig. 227, it will be seen that the steam-port is closed by the exhaust-edge of the valve, or compression begins some time before the piston reaches the end of the stroke. The result is that the remaining portion of the cylinder, through which the piston must move *after* the port is closed to the exhaust, is filled with steam of atmospheric pressure, or possibly a little above that pressure. As this is confined in the cylinder, it is compressed by the advance of the piston. If there was no room between it and the

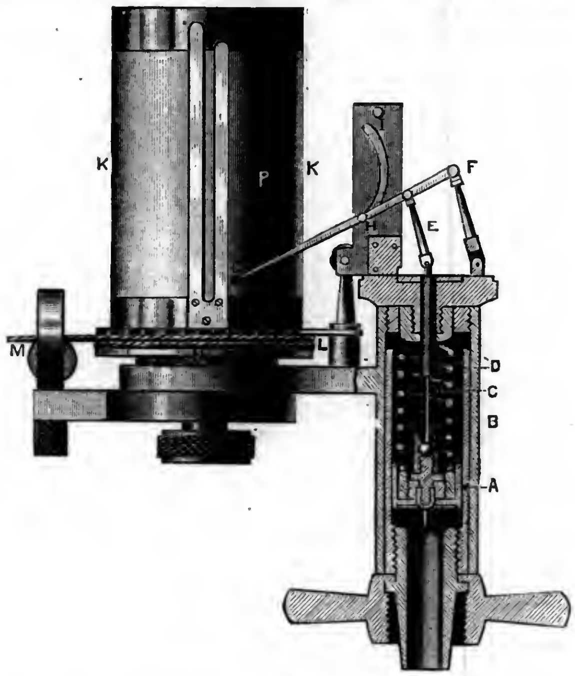


Fig. 233.

cylinder at the end of the stroke, then either the cylinder would be burst or the valve would lift so as to allow the compressed steam to flow back into the steam-chest. The clearance and the steam-passages, however, afford considerable room, into which the confined steam can be compressed without danger of bursting the cylinder or of raising the slide-valve when there is steam in the steam-chest. As the clearance spaces and steam-ways must be filled with high-pressure steam at the beginning of each stroke, it must be obtained either by taking a supply of "*live*" * steam from the steam-chest, or by compressing into the clearance spaces the low-pressure steam that still remained in the cylinder when the port was closed to the exhaust. By the latter process, a certain quantity of steam is saved at the expense of increased back pressure. It should be borne in mind also that the total heat of the compressed steam increases with its pressure, and as its pressure approaches that in the boiler, its temperature must also be raised from that due to about atmospheric pressure to near that in the boiler. These changes of temperature which the steam undergoes will affect the surface of the metal with which the steam is in contact during the period of compression ; it follows from this, that the ends of the cylinder principally comprising the clearance spaces must acquire a higher temperature than those parts where expansion only takes place. This is an important consideration, since the fresh steam from the boiler comes first in contact with these spaces, and by touching surfaces which have thus previously been heated, as it were, by the high temperature of the compressed steam, less heat will be abstracted from the fresh steam, and therefore a less amount of water will be deposited in the cylinder.†

It will thus be seen that the effect of compression is to fill the clearance spaces and steam-ways with compressed steam before pre-admission begins. As already stated, this is done at the expense of back pressure in the cylinder. It must be remembered that all the energy, excepting that part which is wasted by loss of heat, friction, etc., which is consumed in compressing the confined steam, is again given out to the piston by expansion. The confined steam also acts as an elastic cushion to receive the piston, just as the steam which is admitted before the end of the stroke would if there were no compression. Compression, therefore, has the effect of saving the quantity of live steam which it would otherwise be necessary to admit before the end of the stroke to fill the clearance spaces and steam-ways,

* The term "live" steam means steam taken direct from the boiler and which has not been used in the cylinder or to do any work.

† Bauschinger's Indicator Experiments on Locomotives.

and also to "cushion" the piston. As already stated, the momentum of the piston and other parts depends upon their weight and the speed at which they are working, increasing directly as the square of the speed, from which it follows that the compression should increase rapidly with the speed and should be the greatest at high speeds. As the ports are prematurely closed to the exhaust with the shifting-link motion, and as the lead increases rapidly as the link approaches mid-gear, and the amount of compression is at the same time correspondingly augmented, it will be seen that the shifting-link motion fulfills these conditions very perfectly.

The pressure to which the confined steam will rise depends, of course, upon the amount of the period of compression, and also on the size of the clearance spaces. As it is possible to have such an amount of compression that it will exceed the boiler pressure, and thus raise the valve from its seat and be forced back into the steam-chest, some care must be exercised to proportion the one to the other, so that the degree of the confined steam may not be excessive.

QUESTION 361. *How can the effect of the distribution of the steam upon its action in the cylinder be determined by experiment?*

Answer. As already explained in answer to Question 88, this can be done by an instrument called a steam-indicator.

multaneously with the position of the piston; the latter must travel while the action is taking place, and thus the diagram shows changes of pressure later or more gradually than they occur.* To overcome these and other difficulties, the piston-rod of the indicator which we have illustrated is attached by a link, E, to the lever $F\ G$, which carries a pencil, G. By this means the piston has only one fourth of the motion that it imparts to the pencil, so that the momentum of the moving parts is comparatively slight.

In order that the pencil may draw a straight line instead of a curved one, a roller is attached to the lever at H. This moves in a curved slot, $H\ I$, which causes the end G to move in a straight line instead of the arc of a circle. The levers and all the parts, are, of course, all made as light as possible, so that their weight will have little effect on the motion of the indicator piston.

The paper or card, $P\ P$, on which the diagram is drawn, is wrapped around a brass cylinder, $K\ K$. This cylinder is made to revolve part of the way around by a strong twine, $L\ M$, which is wrapped around a pully, N, at the bottom of the cylinder. The twine is attached to a lever, similar to that shown in fig. 38, which receives a reciprocating motion from the piston of the engine. The twine can, of course, move the cylinder

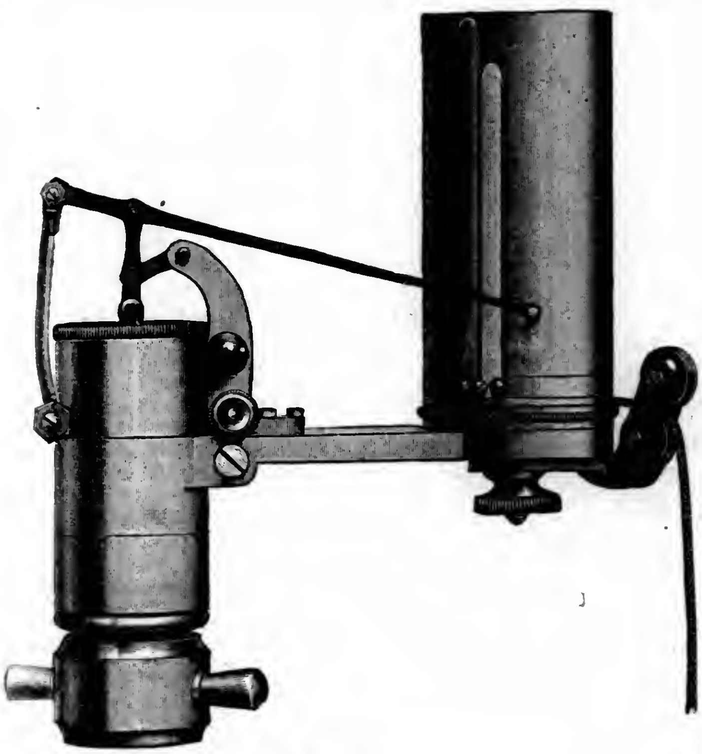


Fig. 234.

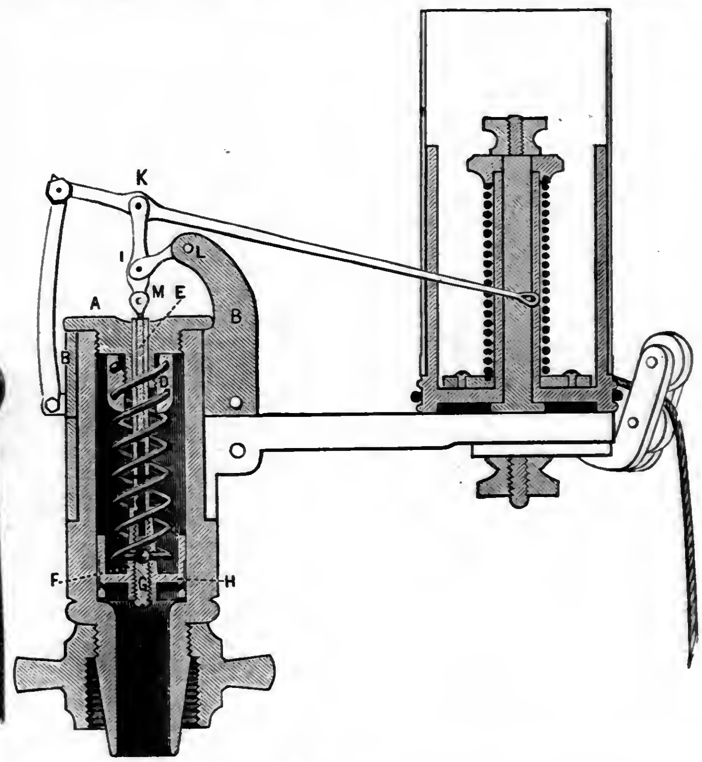


Fig. 235.

QUESTION 362. *What is the construction of this instrument?*

Answer. Fig. 233 represents the Tabor indicator.* It consists of a cylinder, B (which is shown in section), into which a piston, A, is accurately fitted, but so that it will move freely in the cylinder. The piston-rod C is surrounded with a spiral spring, D, the lower end of which is attached to the top of the piston, and the upper end to the cylinder cover. When steam is introduced below the piston it pushes it up in the cylinder, and the spring is compressed. If there should be a vacuum below the piston, the air above it will press the piston downward and extend the spring. This latter occurs only when the indicator is used on condensing engines. Of course the distance which the piston is forced up by the steam-pressure below it depends upon the amount of pressure and also on the tension of the spring; and therefore if a pencil was attached to the piston-rod so that it could mark on a moving card in front of it, a diagram would be drawn, which would indicate the steam-pressure, as was explained in answer to Question 88. But there are some practical difficulties in the way of doing this. It is found that if the pencil is attached directly to the piston-rod of the indicator, the distance through which they must move, in order to make the scale of the diagram sufficiently large to be clear, is so great that the momentum of the parts carries them farther than the pressure of the steam alone would move them. The distance through which the piston would move, moreover, makes it impossible that the changes of pressure should be indicated si-

only in one direction, and therefore a coiled spring similar to a clock spring is placed inside of the cylinder to draw it back when the twine is relaxed. In this way the paper cylinder or drum receives a part of a revolution at each stroke of the piston and moves simultaneously with it. This drum is used instead of a flat card shown in fig. 38. The motion of the paper on this drum will, however, be exactly the same in relation to the pencil as the motion of a flat card would be.

Fig. 234 is an outside view, and fig. 235 a section of the Crosby † indicator, which is similar to the one just described, excepting the mechanism for producing a rectillinear motion of the pencil, which differs somewhat from the other, as is shown in the engravings.

The method of attaching an indicator to a locomotive is represented in fig. 236. It will be seen from this that it is placed over the middle of the steam-chest and is connected to each end of the cylinder with $\frac{3}{4}$-in. pipes. A three-way cock is placed at the point A where the horizontal pipe connects with the vertical one leading to the indicator, by which steam can be entirely shut off from the indicator or communication can be established with either end of the cylinder. The arrangement of the levers for giving motion to the indicator drum and that of the seat, which is very requisite for the experimenter, will be readily understood from the engraving without further explanation. It is thought by some engineers that the indicator

* Manufactured by the Ashcroft Manufacturing Company, 111 Liberty Street, New York.

* Richards's Steam Indicator, by Charles T. Porter.

† Manufactured by the Crosby Steam Gage & Valve Company, of Boston.

should be applied as near to each end of the cylinder as possible. It is believed, though, that if the pipes, cocks, and their connections are made large enough so as not to impede the motion of the steam, no appreciable error will arise from the method illustrated in fig. 236.

QUESTION 363. *What is the form of an indicator diagram?*

Answer. This depends upon the pressure of the steam, the action and proportions of the valve, the speed of the engine, and a variety of other circumstances. To show the influence of the action of the valve, it will be supposed that an indicator diagram is taken with a valve like that shown in fig. 49, and that its movement is represented by the two motion-curves shown by heavy lines in fig. 218.

It should be explained, first, that with ordinary indicators the size of the diagrams is from 3 to 4 in. long and 1½ to 2 in. wide. Therefore the springs which resist the steam pressure under the indicator-piston are made of varying degrees of tension, which are designated as Nos. 4, 8, 12, 16, 20, 30, 40, 50, 60, 80, 100. The number of the spring represents the pressure in pounds per square inch required to compress it sufficiently to move the pencil vertically 1 in. on the diagram. Therefore, by dividing the boiler pressure in pounds by the desired height of diagram in inches, the result will be the number of the spring required. A boiler pressure of 140 lbs. per square inch will be assumed, so that if the diagram is not to exceed 1¾ in. in height, a number 80 spring should be used.

Fig. 237 is supposed to represent an indicator diagram which would be made by the valve, shown in fig. 218, when its movement is as represented by the heavy motion-curve. The horizontal line *m n* represents the line which would be drawn by the pencil of the indicator if the card was moved horizontally when there is only atmospheric pressure above and below the piston. The pencil is supposed to stand at *G* at the beginning of the backward stroke of the piston. As the valve has $\frac{1}{16}$ in. lead it opens the steam-port a little before the piston reaches the end of the stroke. While the crank is moving past the dead point the valve has considerable movement, so that if the engine is moving slowly steam of full boiler pressure will be admitted into the cylinder, and the piston of the indicator will be forced upward, and the pencil will draw the line, *G A*, which is called the "*admission line.*" At the beginning of the stroke the valve opens the port quickly, and it remains open until the piston has reached 21½ in. of its stroke, and during that period the pencil draws the horizontal line, *A B*, which is called the "*steam line.*" When the pencil gets to *B* the steam-port is closed and the steam is *cut off* or confined in the cylinder and then expands, and the pencil draws the line, *B C*, which is called the "*expansion curve.*" *B* is therefore called "*the point of cut-off.*" When the pencil reaches *C*, the exhaust-port is opened and the steam escapes, so that the pressure is rapidly reduced, and the spring above the indicator-piston forces it down and the pencil draws the line *C D E*. *C* is called the "*point of release,*" and *C D E* the "*exhaust line.*"

During the return stroke of the piston, not all the steam escapes from the cylinder, and, especially if the speed is rapid, there is more or less "*back pressure,*" as it is called, in front of the piston, which causes the pencil to draw a line, *E F*, called the "*back-pressure line,*" somewhat above the atmospheric line, *m n*. Before the piston reaches the end of its return stroke the port is closed to the exhaust, and the steam and air enclosed in the cylinder is compressed by the advancing piston, so that the indicator pencil draws the line, *F G*, called the "*compression curve.*" The point *F* is called the "*point of compression*" or "*point of exhaust closure.*"

Fig. 238 represents the form of diagram which would be made by the valve, if its movement was as represented by the smaller motion-curve drawn in light lines in fig. 218. In this and the following diagram the vertical lines represent inches of the stroke, and the horizontal lines and scale on the left the steam-pressure in pounds per square inch. It will be seen that steam is cut off at 16 in. instead of 21½ in. Release occurs at 21 in., and compression begins at a point 2 in. from the end of the stroke.

Fig. 239 is such a diagram as would be made when steam is cut off at 8 in., and in fig. 240 expansion begins at 4½ in. In order to make these diagrams clear a scale of the indicator spring is drawn on the left side of the engraving, and the horizontal lines on the diagram represent the steam-pressure, and the vertical lines indicate inches of the stroke of the piston.

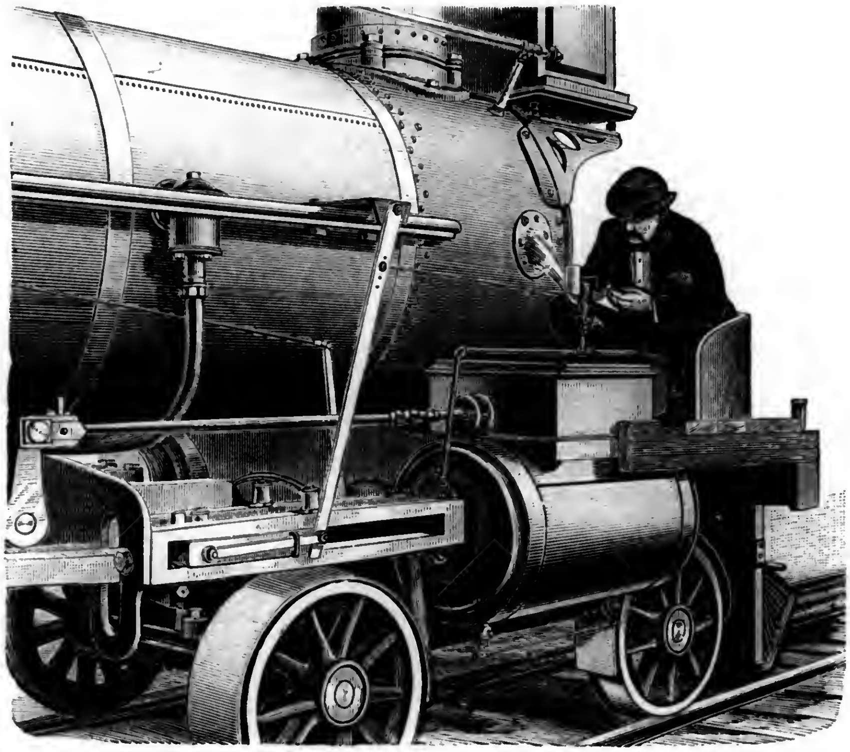


Fig. 236.

QUESTION 364. *What should be the form of an indicator diagram, if the steam is distributed by a link-motion so as to produce the best practicable action in the cylinders?*

Answer. It should approximate to that shown in fig. 241. The atmospheric and vacuum lines *m n* and *o p* are indicated, as already explained. The points at which the different periods of the distribution begin are indicated by small circles, and the letters *A*, *B*, *C*, *D*, *E*, *F*, *G*, and *H*.

The diagram represents a distribution of steam produced by a valve having ⅞ in. outside and $\frac{1}{16}$ inside lap. The eccentrics have 5 in. throw, and the steam-ports are 1¼ and the exhaust 2⅜ in. wide. The valve is cutting off at 8 in., or one-third of the stroke. Pre-admission begins at *G*. when the piston still has 1 in. to move before reaching the end of its stroke. Admission, of course, begins with the stroke, expansion at 8 in., release or exhaust at 17 in., and compression at 16 in. of the return stroke. The valve is supposed to be set with $\frac{1}{16}$ in. lead at full stroke. When the steam is cut off at 8 in. of the stroke, the valve has 2⅝ in. travel and ¼ in. lead. The steam-pressure in the boiler is supposed to be 140 lbs. above the at-

mosphere. Of course when the valve cuts off at different points of the stroke, the periods of distribution will be somewhat changed; but from the above diagram the principal features of a good distribution can be explained.

These are: First, that the steam-pressure should rise rapidly during the period of pre-admission, so that there will be nearly full boiler pressure in the cylinder at the beginning of the stroke. When this occurs, the pre-admission line will rise from *G* to such a point as will indicate nearly or quite full boiler pressure in the cylinder. The same pressure should then be maintained in the cylinder during the whole period of admission, and the admission line from *A* to *B* should therefore approximate to a straight horizontal line. When expansion begins, the pressure will fall, as was explained in answer to Question 88. The expansion line should approximate to a hyperbolic curve, but in laying out this curve allowance must be made for the clearance space between the piston and cylinder heads and the contents of the steam-ways. The cubical contents of these at each end of the cylinders of locomotives are usually from 5 to 10 per cent. of the space swept through by the piston. It will be assumed that this is equal to the space swept by the piston in moving two inches. A line, *I J*, is therefore drawn, two inches from *A O*, which represents the front end of the cylinder, and the space *I J O A* will represent the clearance. When the piston has moved 8 in., then, the steam in the cylinder, instead of filling only the space through which the piston has moved, which is represented by *A O K B*, also fills the clearance space and is represented by *I J K B*. Therefore, in laying out the expansion curve, *B C r*, we must calculate for the expansion of a quantity of steam sufficient to fill the cylinder in front of the piston *and* the clearance spaces, and which is represented by the area *I J K B*. If there is much loss of heat by radiation or other causes, the diagram will fall considerably below the theoretical curve. With cylinders well protected and with dry steam the expansion line will fall slightly below a hyperbolic curve at the beginning of the period of expansion, and rise above it during the latter part of the same period. The reason of this is that the cylinder is heated by the admission of live steam of comparatively high temperature, so that when the pressure becomes reduced by expansion, a part of the water which is condensed in the cylinder will be re-evaporated by the heat in the latter. From the point of the release or exhaust, *C*, to the end of the stroke *D*, the exhaust line should fall rapidly, so that there will be no pressure behind the piston during its return stroke. To explain the theoretical form of the exhaust line would lead into a very abstruse discussion, which would be out of place here. It will be sufficient for our purpose to call attention to the fact that the pre-release should allow as much of the steam in the cylinder to escape as is possible before the piston reaches the end of the stroke, so that the back pressure during the return stroke may be low. It is, however, only at comparatively slow speeds that the steam in locomotive cylinders escapes during the period of pre-release, so that the back pressure is reduced to that of the atmosphere. It is essential in locomotives, as has already been explained, to contract the area of the blast orifices or exhaust nozzles, in order to stimulate the draft through the fire, so that the steam cannot escape with sufficient rapidity to reduce the back pressure to that of the atmosphere if the engine is running fast. Of course every pound of back pressure on the piston is equivalent to an equal amount deducted from the effective pressure on the other side.

QUESTION 365. *How can the net effective pressure on the piston be shown by indicator diagrams?*

Answer. This can be done by taking two indicator diagrams on the same card from opposite ends of the cylinder, as shown in fig. 242. The area *A B C D P O* and *A' B' C' D' O P* represent the absolute pressures in front of the piston during the backward and forward strokes. The areas *H G F E D P O* and *H' G' F' E' D' O P* represent the absolute pressures on the opposite side of the piston or the back pressure. As the one must be deducted from the other to get the net pressure we have *A B C* 2 *F F G H* and *A' B' C'* 1 *F F' G' H'* as the areas which represent the net forward pressure on the piston. At each end of the stroke the back pressure exceeds the forward pressure, and therefore we have the two areas *H* 1 *D'* and *H'* 2 *D*, shaded black, which represent the retarding effect on the piston at each end of the stroke. The length of the vertical lines between the curves *A B C* 2 and *H G F F'* 2 will give the effective pressure, and similar measurements on the black areas will give the retarding pressures for any point of the stroke. This will be made still clearer if we take a line, *H D*, fig. 243, as the line of no pressure on the piston and then lay off vertical lines equal in length to those between the curves *A B C* 2 and *H G F F* 2 of fig. 242, and draw a curve *A B C* 2, fig. 243, through their extremities. This curve will represent the net pressure on the piston, and by laying off vertical lines below *H D* equal in length to those in

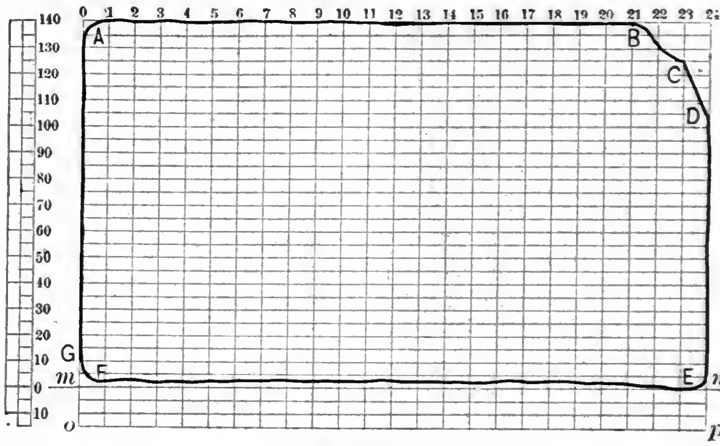


Fig. 237.

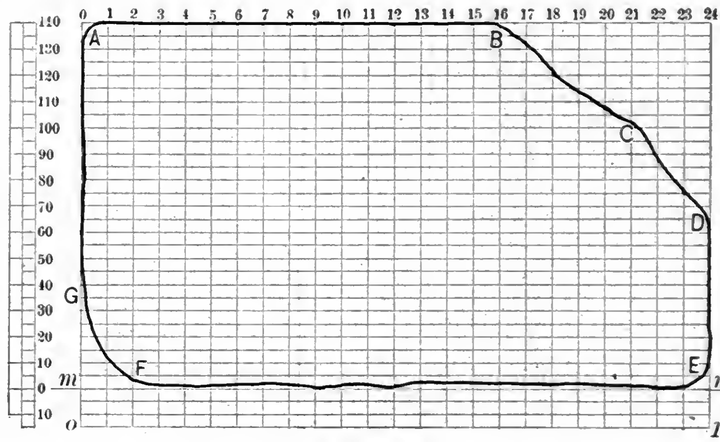


Fig. 238.

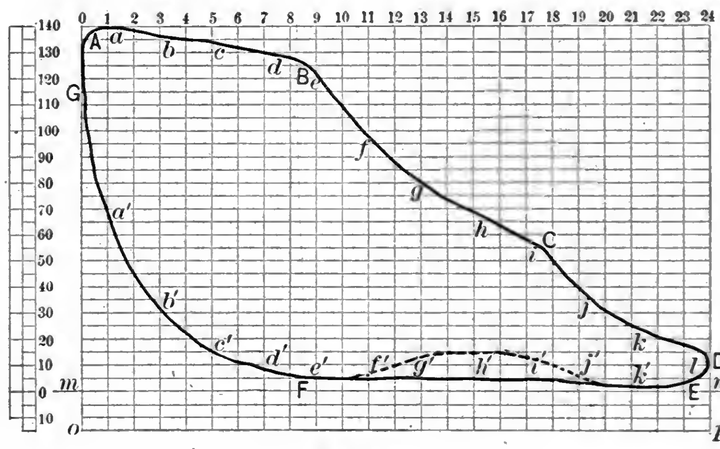


Fig. 239.

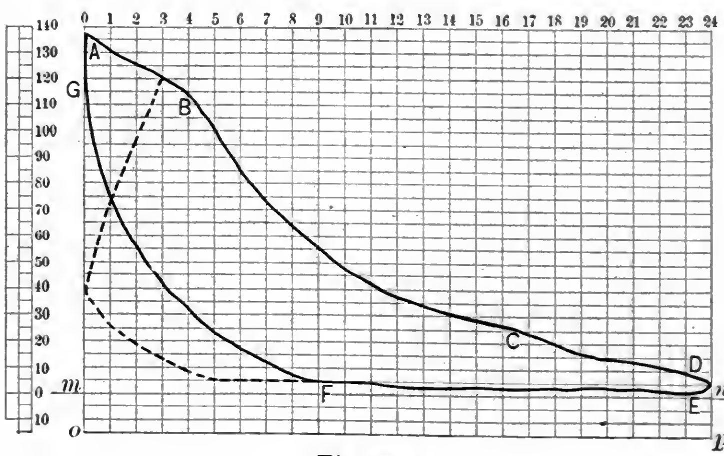


Fig. 240.

the area $H\ D$ 2, and drawing 2 H' through their extremities, this curve and the area 2 $H'\ D$, colored black, will represent the net back pressure on the piston.

In studying the distribution of steam and designing valve-gear every effort should be made to reduce the back pressure, excepting at the end of the stroke, as much as possible, and yet maintain a sufficient supply of steam, and therefore the line of back pressure should conform as closely as possible to the atmospheric line. The compression line should approximate to a hyperbolic curve, beginning with the period of compression. In calculating expansion, allowance must be made for the clearance space and steam-way as has already been explained. The same thing is true of the compression. This must occur in the above example when the piston has 8 in. more to move before completing its stroke. There is therefore a quantity of steam in front of it sufficient to fill a cylinder 10 in. long. This steam is, of course, compressed by the advance of the piston, and if its absolute pressure when compression begins is the same as that of the atmosphere, or 15 lbs., then it will be 18.75 lbs., when the piston has only 6 in. to move, and 25 and 37.5 lbs. absolute pressure when the piston has 4 and 2 in. to move, and when pre-admission begins, the pressure will have risen to 75 lbs. If the back pressure is above that of the atmosphere, of course the compression will be correspondingly increased. It will also be seen that, without any or with very little clearance space, the compression would at the end of each stroke rise above the boiler pressure. It being a peculiarity of the ordinary shifting-link motion that as the period of admission is reduced that of compression is lengthened, the latter becomes very great when the steam is cut off at less than one-third or one-fourth of the stroke.

QUESTION 366. *In what respect would a diagram made by an indicator differ from the theoretical form represented in fig.* 241?

Answer. It would be drawn with less exactness—that is, the corners instead of being sharply defined, as in fig. 241, would be more or less rounded, as shown in figs. 237 to 240, and the curves and lines would vary somewhat from the exact mathematical form indicated in fig. 241. The higher the speed at which the engine is working when the diagrams are taken, the greater will be the variation from the theoretical form.

QUESTION 367. *If the amount of pre-admission is insufficient, how will it be shown in the indicator diagram?*

Answer. The effect of too little pre-admission is to lower the pressure of the steam at the beginning of the stroke, and at high speeds there will not be time enough nor sufficient opening of the steam-port to supply the deficiency after the stroke has commenced. The effect of this is shown by the dotted lines in fig. 240, which show that full pressure was not reached until some time after the beginning of the stroke. With a link-motion if steam is cut off short the port is opened but a small distance, which is sufficient to maintain the pressure at the beginning of the stroke, when the piston is moving comparatively slowly. But when the piston has moved a short distance, its motion is accelerated and the port is being gradually closed by the valve, and the area available for the admission of the steam is gradually diminished. Consequently, the steam cannot enter fast enough to follow the piston, and the pressure falls, so that the admission line, $A\ B$, is no longer horizontal, but droops, as shown in figs. 239 and 240.

Another cause of loss of pressure at the commencement of the stroke, when the steam is worked expansively, is the partial condensation of the entering steam, which takes place in consequence of its coming in contact with the sides of the port and walls of the cylinder, which have been previously cooled down by contact with the exhaust steam of the preceding stroke. This condensation of the fresh steam causes a very serious loss of efficiency in the steam-engine.*

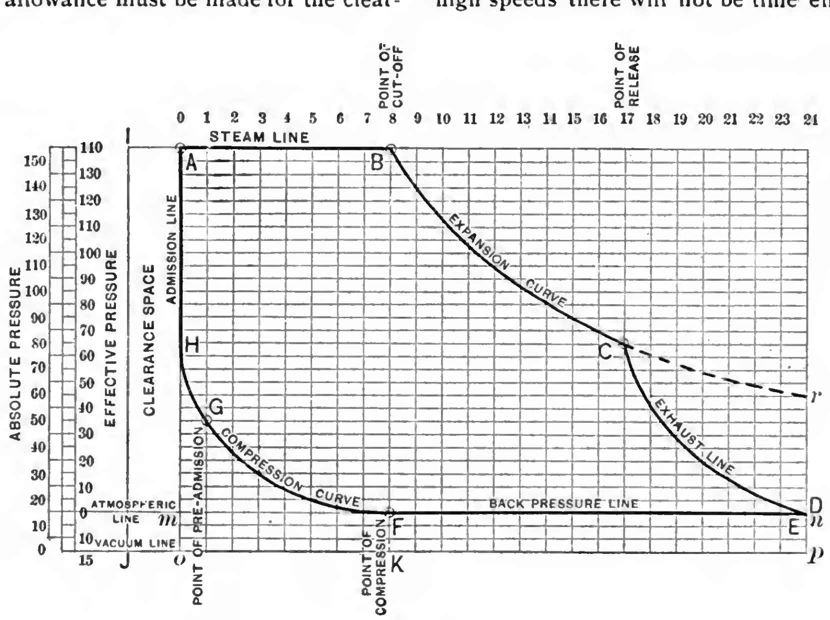


Fig. 241.

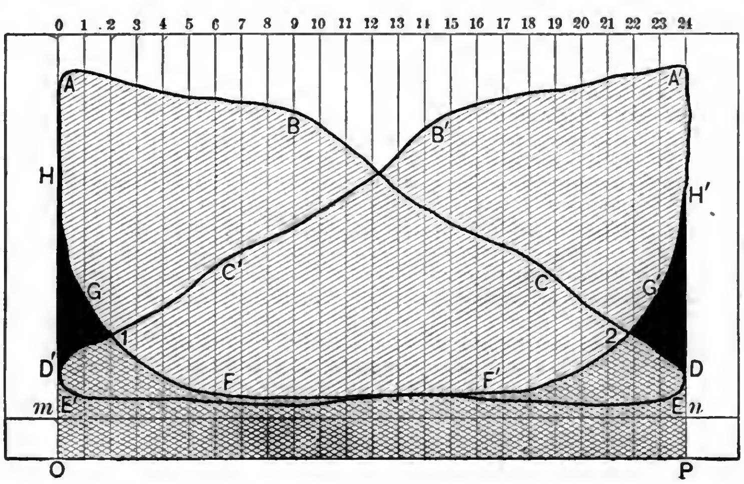


Fig. 242

* The Steam-Engine, by George C. V. Holmes.

QUESTION 368. *If the opening of the steam-ports during admission is too small, what will be the form of the diagram?*

Answer. The effect will be very much the same as that produced by too little pre-admission or lead—that is, the pressure in the cylinder will be much lower than in the boiler and will fall rapidly during the periods of admission, as shown in fig. 240.

QUESTION 369. *What defects will be indicated by the expansion curve of indicator diagrams?*

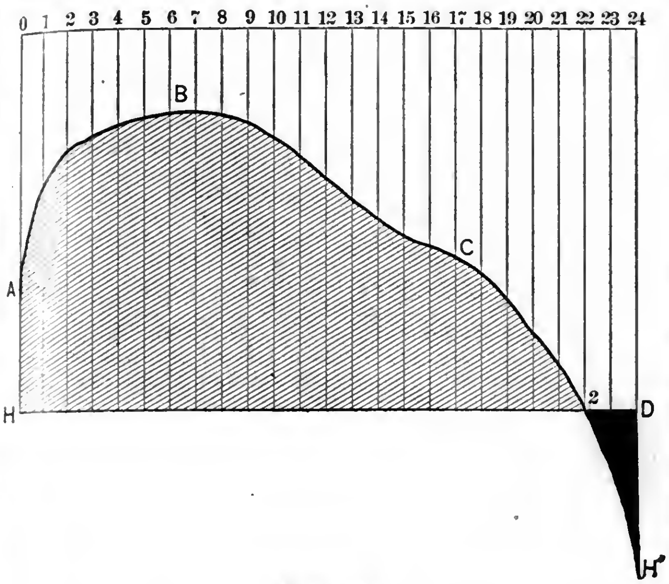


Fig. 243.

Answer. If the cylinders are not well protected, and there is much loss of heat from radiation, there will be a rapid fall of pressure during the period of expansion, which will be shown by the expansion curve falling below the theoretical curve. If, on the contrary, the indicator curve is much above the theoretical curve, it may be caused by a leak in the valve. As steam is quite as likely to leak from the steam-port into the exhaust as from the steam-chest into the steam-port, a valve which is not tight may produce just the contrary effect upon the indicator diagram. As it is usually quite easy to detect a leak in the valve by other means, the use of the indicator for this purpose is unnecessary. Attention is called to it, however, to show the impossibility of getting results of any value with the indicator if the valves are not steam-tight.

QUESTION 370. *What should be observed regarding the exhaust line of the indicator diagram?*

Answer. The most important point to be observed is, whether the pressure at the end of the stroke is reduced as low as possible, as at high speeds it is usually much more difficult to exhaust the steam from than to admit it into the cylinder. As already stated, the blast in the chimney makes it almost impossible to exhaust the steam to atmospheric pressure when the locomotive is running fast. If the steam is released too late in the stroke, as already explained, there will not be time enough nor sufficient opening of the port to allow the confined steam to escape from the cylinder before the end of the stroke, and this will be indicated on the diagram by the space between the line of back pressure and the atmospheric line during the commencement of the return stroke, as shown in figs. 242, 244.

QUESTION 371. *What should be observed regarding the line of back pressure?*

Answer. The most important point is, that it should approximate as closely as possible to the atmospheric line, as all the back pressure not only diminishes the efficiency of the engine, but is a total loss of energy. Too much inside lap will increase the amount of back pressure, but generally it is more influenced by the area of the blast orifices than by any other cause. Every effort should be made, therefore, to have them as large as possible, and yet have the boiler make as much steam as is needed.

When only one blast orifice is used for both cylinders, it often happens that when the steam is exhausted from the one cylinder it "blows" over into the other, and thus produces an additional amount of back pressure. This is shown by a rise or "hump" in the line of back pressure, as indicated by the dotted line *f g' h' i' j'* in fig. 239.

QUESTION 372. *What good effects result from compression?*

Answer. It serves to arrest the motion of the piston at the end of the stroke. As was explained in Chapter VIII. the motion of a piston in the cylinder of a steam-engine is not a uniform one, but increases in speed from the beginning of the stroke to the middle, and diminishes in speed from the middle to the opposite end. It is obvious that if the momentum, or actual energy stored up in the piston and other reciprocating parts after they have passed the middle of the stroke, added to the pressure behind the piston, is greater than the resistance offered by the crank, the motion of the latter will then be accelerated and thus conveyed to the moving engine and train. If, however, there is any momentum in the piston when it reaches the end of the stroke, evidently it can exert no power to cause the crank to revolve, but must be expended by producing a pressure on the crank-pin and thus on the axle-boxes. Not only will such a pressure not cause the crank to revolve, but it will be more difficult to turn the crank with such a pressure against it than it would be without. The momentum of the piston and other reciprocating parts at the dead point, therefore, creates a resistance to the movement of the crank instead of helping to turn it. It will also be observed that after the crank has moved slightly from the dead point, any pressure on the piston will exert very little force which will tend to turn the crank. In fact, the nearer the piston is to the end of the stroke the greater is the proportion which the friction of the crank-pin and axle bears to the useful effect of the strain in causing the crank to turn. Calculation shows that for about three degrees on either side of the dead points the effect of pressure on the crank-pin is actually to retard the engine. If, then, the piston reaches the end of the stroke with a certain amount of momentum stored up in it, which is expended by producing pressure on the crank, then it will not only be a waste of energy but a double waste by retarding the motion of the crank. If, however, this energy can be absorbed by compressing steam which will fill the clearance spaces, it will not only prevent the retarding effect referred to, but the energy in the piston and other parts will be converted into steam pressure, which will be given out in useful work during the next stroke. It would, of course, be impossible to arrest the motion of the piston instantly, and therefore its momentum is gradually absorbed from the time compression begins until it reaches the end of the stroke. As the energy of a moving body is equal to its weight multiplied by the square of its speed, it is obvious that to overcome this a different amount of compression would be required for each speed, and also that it must be adjusted to the weight of the moving parts. Such adaptation is not practicable on locomotives, nor does the link-motion enable us to alter the amount of compression with so much exactness; but the explanation

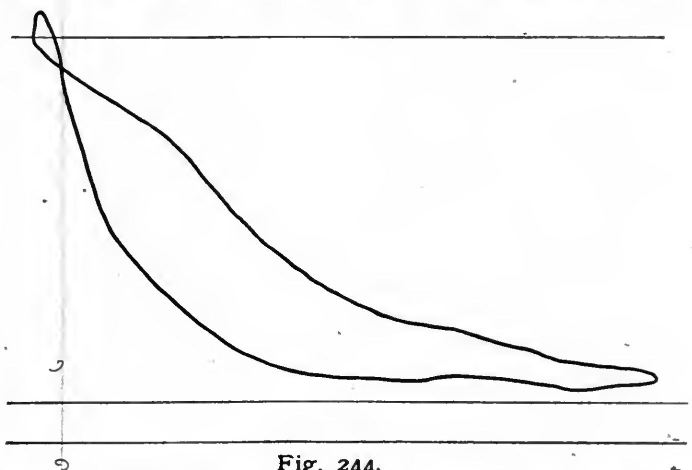


Fig. 244.

shows the value of increasing the amount of compression with the speed, which fortunately the peculiarities of the shifting-link motion enable us to do without difficulty.

QUESTION 373. *How does a link-motion increase the amount of compression with the speed?*

Answer. When a locomotive is running fast the steam is cut off short, and the lead and the amount of compression increases as the period of admission diminishes.

QUESTION 374. *What cause produces the form of diagram represented by fig. 244?*

Answer. It is produced by excessive compression, which causes the pressure in the cylinder to rise above boiler pressure before pre-admission begins. As soon as the port is opened, part of the steam in the cylinder flows back into the steam-chest, and thus the pressure is reduced, as shown by the diagram.

QUESTION 375. *What will an indicator diagram show?*

Answer. It will show:

1. The pressure of steam in the cylinder at the beginning of the stroke of the piston, or the *initial pressure*, as it is called.

2. Whether the initial pressure is increased or diminished during the period of admission.

3. The point of cut-off.
4. The pressure during the whole period of expansion.
5. The point of release—*i.e.*, when the exhaust is opened.
6. The rapidity with which the exhaust takes place.
7. The back pressure on the piston.
8. The point at which the exhaust is closed.
9. The compression after the exhaust is closed.
10. The power which is driving the engine.
11. Leakage of the valve or piston.

QUESTION 376. *What are the principal causes which affect the form of the diagram?*

Answer. 1. The friction of the steam in the pipes and ports.

2. The variable size of the openings of the steam-ports as caused by the gradual motion of the slide-valve.

3. The action of the internal surfaces of the cylinder in causing condensation and partial re-evaporation of some of the entering steam.

4. The steam contained in the clearance spaces which affects the curve of expansion.

5. The gradual opening of the exhaust-port, which makes it necessary to release the steam too early in the stroke.

(TO BE CONTINUED.)

Manufactures.

Electric Street Railroads.

THE People's Railroad Company in Scranton, Pa., which operates 12 miles of track, has ordered 20 new cars equipped with the Sprague electric motor, and also the necessary stationary plant.

THE Thomson-Houston Electric Company, of Boston, has bought the Hoosac Valley Street Railroad, running from South Adams to North Adams, Mass., and will put up a large electric plant. The road will be run by electricity, and opportunity will be taken to experiment with different motors.

Blast Furnaces of the United States.

THE *American Manufacturer's* tables show the condition of the blast furnaces on July 1, as follows:

Fuel.	In Blast. No.	In Blast. Weekly capacity.	Out of Blast. No.	Out of Blast. Weekly capacity.
Charcoal	68	12,753	104	12,161
Anthracite	96	28,176	104	27,173
Bituminous	119	74,743	103	52,743
Total	283	115,672	311	92,077

There was a decrease of 15 furnaces in blast and 7,343 tons capacity during June. The number of furnaces in blast, as compared with that a year ago, was as follows:

Fuel.	July 1, 1888. No.	July 1, 1888. Weekly capacity.	July 1, 1887. No.	July 1, 1887. Weekly capacity.
Charcoal	68	12,753	77	13,969
Anthracite	96	28,175	136	37,662
Bituminous	119	74,743	101	57,355
Total	283	115,672	314	108,986

The total production of pig-iron for the first half of 1888 is estimated at 2,950,000 tons, a decrease of about 99,000 tons as compared with the first half of 1887.

Marine Engineering.

THE new steamer *Monmouth*, built at Cramp's yard in Philadelphia, for the Central Railroad Company of New Jersey, has just been put in service. The new vessel is sponson built and schooner rigged, 260 ft. long, 35 ft. extreme beam, and 15 ft. 9 in. deep. Her registered tonnage is 1,490 and draft of water 10 ft. aft and 9 ft. forward. She has main, promenade, and hurricane decks. The arrangements for the comfort of passengers are tasteful and commodious. Her saloon is finished in antique oak, handsomely carpeted, having large private apartments opening into the main saloon, and some 30 private rooms for the accommodation of those desiring them. The vessel is lighted throughout with the incandescent electric light. She will be allowed 2,200 passengers.

The machinery consists of a pair of the most modern designed, vertical, triple-expansion twin-screw engines. The cylinders are 19, 30, and 50 in. diameter by 30 in. stroke of piston, and are expected to develop 2,500 H.P. with a steam pressure of 160 lbs. Piston slide-valves on all the cylinders are worked by the Marshall valve-gear; the air pumps are driven off side-levers and the centrifugal circulating pumps by independent engines. The boilers are four in number, 12 ft. diameter by 12 ft. 5 in. long, fitted with Montgomery patent corrugated furnaces made by the Continental Iron Works of Brooklyn, of Spang steel throughout, all rivets being drilled by hydraulic machinery. The vessel is steered by Williamson's patent steam steering-engine, and all the mechanical contrivances are of the most improved type including the Edison dynamo, the Williamson patent ash-hoist, and the fan engines to supply forced drafts to the boilers. The *Monmouth* is intended for day service on the Long Branch route between New York City and Sandy Hook, and is guaranteed to make the run in 55 minutes.

Manufacturing Notes.

THE Keystone Bridge Company, of Pittsburgh, has opened a branch office at No. 55 Broadway, New York, which is in charge of Mr. George B. Mallory as Consulting Engineer and Agent.

THE Smith Bridge Company in Toledo, O., has taken a contract to build a highway bridge over the Potomac River at Point of Rocks, Md.; the contract price is $45,000.

THE Strong Locomotive Company has voted to build shops for the manufacture of its locomotives. These shops will be equipped with special tools and appliances for building the Strong boiler.

THE Rogers Locomotive Works in Paterson, N. J., have recently completed three engines for the Nashville, Chattanooga & St. Louis and seven for the Long Island road; also several heavy passenger engines, with Wootten fire-box, for the Union Pacific.

THE Schenectady Locomotive Works in Schenectady, N. Y., are building a new shop 75×350 ft. These works in June turned out 28 locomotives, as follows: Three 18×24 passenger, and four 20×26 consolidation freight locomotives for the New York Central & Hudson River Railroad; two 18×24 passenger for the Indianapolis & St. Louis; six 17×54 wheel switchers; six 18×22 passenger, and six 18×24 wheel freight locomotives for the Chicago, St. Paul, Minneapolis & Omaha; one 17×24, 8-wheel locomotive for the Meriden, Waterbury & Connecticut River Railroad. The works are employing about 1,400 men.

THE firm of Binsse & Hauschild, of East Newark, N. J., have received the award of one-half of the gun lathes for finishing the parts of the new steel breech-loading rifle guns, the remainder to be awarded when these are completed. These guns are to form the armament of the men-of-war now building. The six lathes for finishing the tubes are to be 130 ft. long each; the three lathes for the jackets are 64 ft. long each, and the seven hoop lathes are about 40 ft. long each. All these tools swing 9 ft. over the bed and 9 ft. across the bed. The hoop lathes will weigh about 100,000 lbs. each. The main spindle bearing is 12 by 20 in., and the face plate, 9 ft. in diameter, will weigh about 10,000 lbs. The beds, two for each machine, will be about 40 ft. long in one piece, and will weigh about 15,000 lbs. each. The tools are to be erected in the Washington Navy Yard.

Cars.

THE Chattanooga Car Works in Chattanooga, Tenn., are building a lot of coal cars for the Chattanooga, Rome & Columbus Railroad.

THE Crossen Car Works at Cobourg, Ont., have recently completed a very handsome sleeping-car for the Intercolonial road.

THE Wason Manufacturing Company at Springfield, Mass., is building several drawing-room cars for the New York, New Haven & Hartford road.

THE St. Charles Car Company at St. Charles, Mo., is building 1,000 freight cars for the Atchison, Topeka & Santa Fé Railroad.

THE new shops which the Canadian Pacific Company is now building in Montreal include a passenger car shop 400 ft. in

diameter and two stories high; wood machinery shop, 400×100 ft., two stories high; blacksmith and machine shop, 300×100 ft., one story; store room, 350×90 ft., two stories high, and a foundry, 150×100 ft., two stories high, all of which are to be built of brick and stone, and which, for the buildings alone, will cost about $300,000. When completed these works will give employment to about 1,000 hands.

THE Missouri Car & Foundry Company in St. Louis has received an order for 735 freight cars for the Louisville & Nashville Railroad.

THE New Glasgow Forge Company at New Glasgow, N. S., has taken a contract to furnish 10,000 car axles for the Canadian Pacific road.

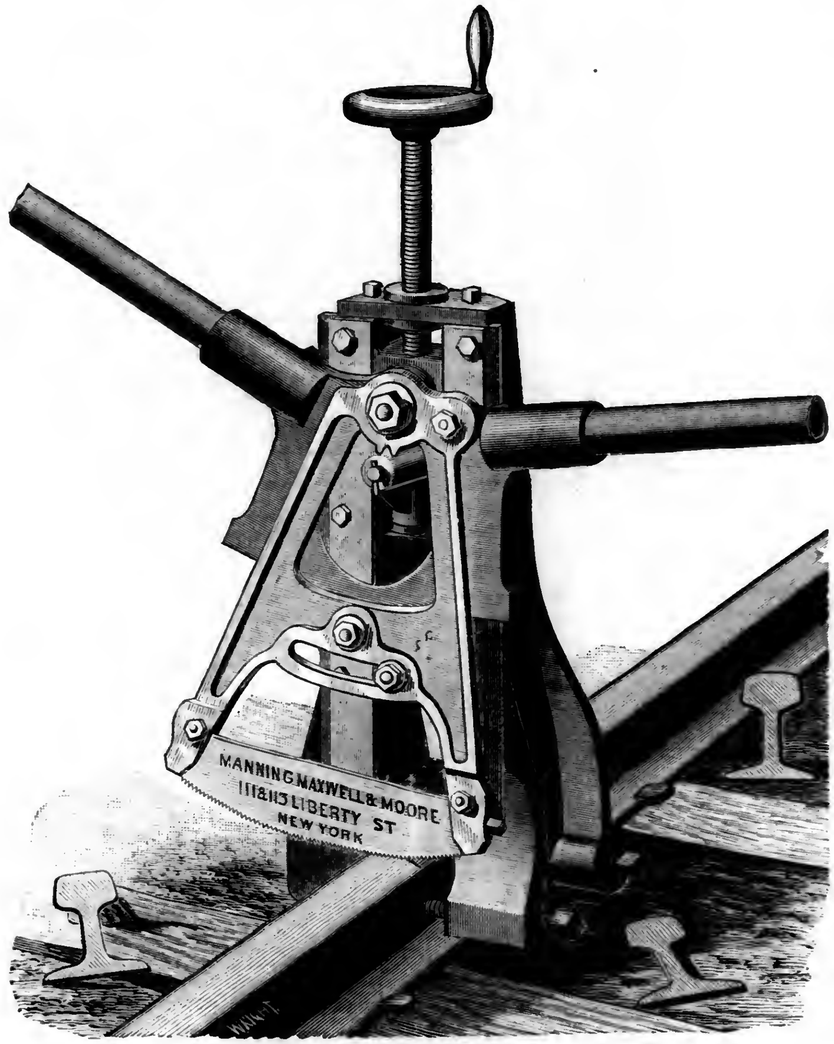
THE Harlan & Hollingsworth Company in Wilmington, Del., delivered three sleeping-coaches to the Boston & Albany Railroad early in July.

THE Fitchburg Railroad Company has begun work on its extensive new car shops at East Fitchburg, Mass. There are to be six buildings in all. Four of them will be placed side by side, and will each be 100 ft. wide by 480 ft. long, covering about 1½ acres, and divided by two cross-walls into three equal sections of 160 ft. each. The first shop will be for car repairs, the next for building freight cars, the third for new passenger coaches, and the fourth for a paint shop. Large transfer tables will be put in between the repair shop and the freight car shop, and between the passenger car and paint shops. Some 15 or 20 tracks will be laid in each shop longitudinally, and by means of the transfer tables a car can be run in or out of either of the shops without interfering with any other car. Across the spur track will be two other buildings, one, 60 ft. by 300, for the wood-working department, and the other, 60 ft. by 400, will be the machine shop, engine, and boiler house. All of the buildings will be of brick, and, with one exception, one story in height, with a monitor roof; the wood-working shop will be two stories high. It is not proposed to erect all the buildings at once, but work will begin on the freight car shop, and will be pushed forward as rapidly as possible, for the increasing business of the road urgently demands largely increased facilities for building and repairing cars.

RIEHLE BROTHERS, in Philadelphia, have recently received orders for one 200-ton and one 50-ton track scale, one transverse tester, several cement testers, and a large number of small scales and testing-machines.

The Smith Portable Rail-Saw.

THE accompanying illustration shows a very valuable machine, intended to cut rails on the track or elsewhere, and to do away with the present method of using the chisel and sledge, thus avoiding not only the extra labor and risk of breakage but the danger of injury to the rail itself. By the use of the saw a very nice adjustment in the length of the rail can be made while the ends are left smooth and square.



SMITH'S PATENT PORTABLE RAIL-SAW.

The machine itself is so simple, and its construction is so plainly shown by the engraving that a lengthy description is hardly necessary. The first saw of this kind was made in 1885, and at that time the inventor cut with it a 60-lb. rail in 35 minutes. In its present perfected form it is claimed that a 70-lb. rail can be cut through in about 12 minutes, and that as thin a cut as ⅛ in. can be taken off.

The saw-blade is carried on pins in the frame, and is made stiff by a nut shown on the end of the frame in the engraving. A saw can be removed and a new one put in very quickly when required.

This machine is in use on a number of prominent roads, and has so far met with approval wherever it has been tried.

This rail-saw was invented by Mr. S. C. Smith, of Brooklyn, N. Y., and is manufactured and sold by Messrs. Manning, Maxwell & Moore, of New York.

The Standard Metal Tie.

THE engravings herewith illustrate a new metal railroad tie which the Standard Metal Tie & Construction Company, of 155 Broadway, New York, is now introducing. As shown by the engravings, each tie is made of a plate of iron or steel ¼ in. thick, which is bent or rolled so that its cross section forms a U-shaped section, shown in figs. 5 and 6. To prevent these ties from moving laterally on the track, a portion of the bottom of each of them is cut away, as shown in figs. 3 and 4. The metal plate next to the opening, which is thus made in the base of the tie, is then bent upward, as shown at *a*, fig. 1, and also in the perspective view, fig. 2. The ballast is rammed into the openings thus formed in the middle of the ties, and it thus bears against the portions of the plates which are bent upward, and resists the lateral movement of the ties.

Fig. 1.

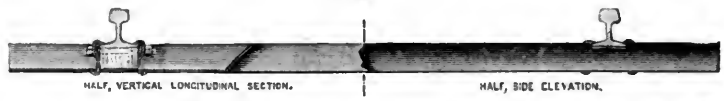


Fig. 2.

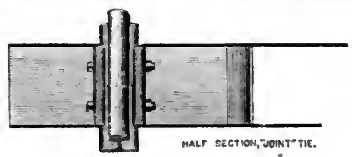


Fig. 3.

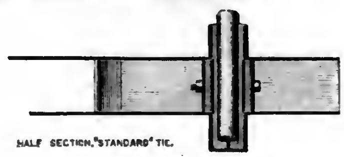


Fig. 4.

The rails are supported on wooden blocks, placed endwise in the trough of each tie, as shown under the left-hand rail in fig. 1, and at *A* in the enlarged sectional view, fig. 6. The rails are held in position by S-shaped clips, *C C*, fig. 6, the lower ends of which hook into openings, *D D*, in the bottom of the ties, and the upper ends hook over the flanges of the rails. A horizontal bolt, *B B'*, passes through each pair of clips and the wooden block *A*. As the clips bear on the inclined top surface of the rail flange when the bolt is screwed up, the rail, wooden block, and tie are all drawn together and securely held in place. The upper edges of the ties are notched to receive the rails, which effectually prevents them from spreading.

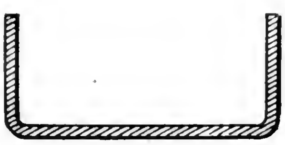


Fig. 5

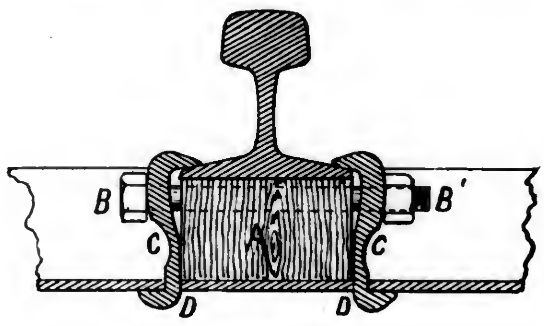


Fig. 6.

Fig. 7.

Fig. 5 shows a section of an ordinary tie, and fig. 7 one of a joint-tie. The latter are made wider than those between the joints. This increased width permits of the use of wider blocks and longer clips, which are fastened with two bolts, as shown in the perspective view, fig 2. These clips and bolts hold the rails securely at the joints, and dispense entirely with the use of fish-plates.

The whole railroad world is now looking for a satisfactory metal tie. The increasing price and scarcity of wooden "sleepers" will soon compel railroad companies to adopt something more durable and less liable to decay than wood. Already on the Continent of Europe metal ties are extensively used, and the depletion of our forests will compel railroad managers to follow the practice of European engineers.

The Richmond Electric Railroad.

(From the *Electrical World*.)

THE Sprague electric motor is now in daily use in Richmond, Va.; the road is a double track line, operated by the Union Passenger Railway Company, from the extreme eastern to the extreme western limits of the city. The line aggregates 13 miles in length, traversing the city by a very ~~circuitous~~ route, which involves a great many sharp curves and several very heavy grades, ranging up to 10 per cent., while there are no fewer than 29 of the curves that require bent rails, 5 of them being less than 30 ft. radius. The cars are electrically of the usual Sprague type, with twin motors, each of 7½ H.P. Each car will carry 40 passengers. The overhead contact is used for obtaining current, by means of a light structure on top of the car. It is a low skeleton framework which carries an adjustable swiveling trunnion, having at its upper end a jaw in which is suspended a counterbalanced trolley pole, having at its extension a grooved wheel making running flexible contact on the under side of the working conductor. On getting at the end of the track this trolley trunnion is swung around so as to trend in a proper direction abaft the center of the car. It is impossible for it to pull the trolley wire down, and if off the line, it can be replaced quickly and easily. From the trolley the current passes through an insulated wire to two switches, one at each end of the car, whence it goes to the motor circuits, and thence to the wheel frame. The return circuit is through the track, and thence by both metallic and ground circuits to the station. Each section of rail is joined to a copper ground wire, which runs throughout the length of the road underneath or alongside

the stringer pieces. At intervals of 500 ft. this ground wire is connected to an earth plate, and at seven points, widely distributed, these ground plates are supplemented by heavy iron pipes sunk into iron ore or 12-in. water wells about 25 ft. deep. The ground wire is connected to the station, and there is also a main ground connection made there in a 30-ft. well through a large sink plate.

The electric circuit consists of two parts—the overhead and the ground circuits, each being of compound character. Along the curb-stones at distances of 125 ft. are 30-ft. poles inserted into the ground a distance of 5 ft. These poles carry the main circuit, which extends throughout the entire length of the road, and is of copper wire $\frac{3}{16}$ in. in diameter. This is the main conductor. The working conductor, of the same size as the main conductor, is carried over the center of the track at a distance of about 18 ft. from the ground on insulators supported by span-wires running across from pole to pole, and provided with additional insulators at their ends. The whole structure is very light looking. This working conductor is connected to the main line at intervals of 500 ft. by short branch wires. The main conductor is itself supplied at four widely separated points by feeders from the central station.

The motive-power plant of this station was designed by Mr. J. H. Vail and built by the Jarvis Engineering Company of Boston. The boilers comprise a battery of three in number, 6 ft. in diameter by 16 ft. long, and easily capable of developing 150 H.P. each; the space is also arranged for extension of the battery to admit of four more boilers of the same size. The boilers are set with the Jarvis furnace to utilize as fuel the slack soft coal which is procured in Virginia at low prices; the furnaces are lined throughout with the best fire-brick, which guarantees greater durability of the work. One large iron smoke-stack 80 ft. high above grate level, 54 in. diameter at base, and 60 in. diameter at top, furnishes a magnificent natural draft to the boilers, enabling them to be worked fully 20 per cent. above their rated capacity. The engines are of the Armington & Sims type, three in number, of nominal capacity of 125 H.P. each, and are belted to the dynamos direct, dispensing with all shafting.

The dynamos are six in number, all connected in multiple arc, feeding into a "bus" line. One side of the "bus" is connected to the ground, and to the other side are connected the feeders. Each dynamo is of 40,000 watts capacity, and is wound for a potential of 500 volts.

Owing to the character of the soil and lack of pavement the road-bed was found to be a source of much trouble; a good portion of the track being laid in mud and clay streets, which in moist weather unsettle the curves, throws the track out of gauge, and permits the accumulation of more or less soil on the rails. Steep grades of 10 per cent., and sharp curves of 27 ft. radius, combined with a 7 per cent. grade, and with the outer rail of the curve nearly 3 in. lower than the inside rail, have been found to be difficulties of no mean importance to overcome.

This road is by far the most important and extensive electric railroad enterprise ever undertaken, and has involved more difficulties and a greater variety of obstacles to the successful application of self-propelled cars, as well as to the employment of electricity, than were ever before attempted. Returns for the week ending May 9 showed an average of 20 cars out per day, running 1,548 miles, or nearly 80 miles each, and carrying 7,378 passengers, at a total cost per car for road operating expenses of $1.98, and of $1.48 for station expenses. In other words, the cost of operating, except official and salary charges, taxes and insurance, is only $3.46 per car per day on an 80-mile run, and this is stated by Mr. E. P. Harris, the well-known street car expert, to be only 40 per cent. of the cost of operation by horses with the same number of cars, with the additional advantage that, in point of fact, the road with animal power, for the same work, would require not less than 25 cars, with a stable equipment of from 275 to 300 horses.

Proceedings of Societies.

Ohio Institute of Mining Engineers.

THE annual meeting was held at Logan, O., July 11 and 12. The programme included the annual address by President W. H. Jennings; and papers on the School of Mines at the State University, by Professor N. W. Lord; on Mining Legislation in Ohio, by Andrew Roy; Shaft Mining on the Sunday Creek Valley, by J. J. Dun; the Fire Clays at Five Mile Creek, by Ellis Lovejoy; the Grading of Pig-Iron, by Edward Orton, Jr. Several of these papers were discussed, and there was also a special discussion on Brick Paving.

The day after the close of the meeting the members went on an excursion, by special train, to the mines of the Hocking Valley region, including, especially, those of Sunday Creek and Brush Fork.

Engineers' Club of Kansas City.

A MEETING was held in Kansas City, June 18. It was voted to extend an invitation to the American Society of Civil Engineers, to hold its next annual convention in Kansas City. In answer to a letter from Mr. C. L. Strobel, of the Western Society of Engineers, with reference to bridge reform, it was voted to secure answers to the following questions by letter ballot from members:

1. Do you favor the appointment of bridge engineers?
2. Do you consider it possible for bridge engineers to adopt a scale of minimum rates for the proper design and specifications of bridges?
3. Are you willing to co-operate by appointing a meeting to report on the scale of minimum rates?

Several additions to the library were reported.

Mr. J. Donnelly read a paper on Street Pavements of Kansas City, which was discussed by a number of the members present.

Car Accountants' Association.

THE thirteenth annual meeting was held in Montreal, beginning on Wednesday, June 20, with a full attendance. The principal subject of discussion was the Per Diem System of Compensation for the Use of Cars, the discussion of which occupied an entire day. The subject was disposed of for the present by the adoption of the resolution instructing the Per Diem Committee to collect statistics covering the service of foreign cars on all the railroads in the United States and Canada for the months of October, 1887, March, 1888, and July, 1888; all members are requested to assist the committee in this matter.

The committee on Routing Foreign Cars presented a report making some valuable recommendations, which were generally approved. There was a long and interesting discussion including many valuable suggestions as to How the Car Service Office may be made more Efficient.

A cipher code, for use in telegraphing about car service matters, was presented by a committee. The meeting, on the whole, was a very successful one.

Engineers' Club of Philadelphia.

THE last meeting for the season was held in Philadelphia, June 16. The tellers reported the following elected members: Henry Roeske, William W. Thayer, J. H. Skinker, James S. Merritt, Henry G. Morse, John M. Cameron, Reynold T. Hall, and W. H. Pratt.

The Secretary called attention to the proposed publication of an index to engineering periodicals by F. E. Galloupe, of Boston. A committee of three was appointed to co-operate with similar committees from other societies in securing action in relation to the improvement of highway bridges. It was resolved to join in the invitation to the International Congress of Geologists to hold its next session in 1891 in Philadelphia. It was also resolved to appropriate $100 from surplus funds of the Club for the benefit of the family of the late W. R. Kütter. The subject of the best form in which to continue to publish the Club reference book was referred to the Board of Directors.

Mr. E. F. Smith presented, for Mr. H. M. Sperry, an illustrated description of a Method of Displaying Titles on Blue Prints, by writing the title, number, etc., along *both* ends of the tracing, and, when printed, folding each end of print backward, in a fold about one half inch or so wide, and pasting it, back to back, so that when the print is on file, rolled, its title will always appear on the outside.

Mr. E. F. Smith presented a very completely illustrated paper upon Dam Building in Navigable Streams.

Professor J. W. Redway read a paper upon the Hydrography of the Mississippi River.

The Secretary presented, for Mr. Rudolph Hering, a Formula

for the Mean Velocity of Flow in Sewers, being a simplification, for field and general use, of Kütter's Formula.

The Club then adjourned until the first Saturday in October.

American Society of Civil Engineers.

THE annual convention began in Milwaukee, Wis., June 28, most of the members attending it having reached the city on the previous day. Special trains of cars were run from New York, Boston, and several other points. Mr. G. H. Benzenberg, of Milwaukee, was made Chairman, in accordance with the usual custom, by which the presiding officer of the Convention is always chosen from among the members resident in the place where it is held. The usual addresses of welcome were made and responded to. The routine business was followed by the reading of a paper on Friction, Waste, and Loss of Water in Mains, by Charles B. Brush, which was discussed by a number of members. At the afternoon session Mr. E. R. Tratman read a paper on English Railroad Track. In the evening the members attended a reception given by the Woman's Club of Milwaukee.

On the second day the morning session was taken up by the reading of a paper by J. T. Dodge on the Destruction of Rails by Excessive Weights and the discussion of the same.

The Committee on Uniform Standard Time reported that the system is making steady progress, meets universal favor on every railroad where it is in use, and that it is gradually being adopted for common public use in Manitoba.

The report was accepted and the Committee continued.

The Committee on Compression of Cement Mortars and Settlement of Masonry was continued and their report accepted and ordered printed.

The Committee to formulate recommendations with reference to titles and grades of engineers on public works, recommended :

1. That the title of chief engineer should be given to one having a supreme direction of work.

2. That the chief assistant engineer should be one who, when the magnitude of the work prevents the personal attention of the chief engineer, shall represent him in communicating with subordinate engineers.

3. That the division engineer should be one directing resident engineers on work whose magnitude prevents such direction from being given personally by the chief or chief assistant engineer.

4. That the resident engineers should be those having direct supervision of work in progress which receives their daily attention.

5. That the assistant engineers should be those employed directly under those above mentioned, in topographical, or instrumental work, or on plans of structures.

6. They deprecate the too frequent use of the title of consulting engineer, which should be used only by those acknowledged as authorities.

7. Specialist engineers may well assume such titles as hydraulic, sanitary, electrical, etc.

8. They recommend the title of chief engineer for the engineer in responsible charge of the public works of a city.

9. When the magnitude of the work does not require a chief assistant or division engineer, the resident, still giving personal daily supervision to all work under his charge, shall rank next to the chief engineer.

It had been a serious question with the Committee whether the titles of division and resident engineers should not be reversed. As some members of the Committee were absent, and the Chairman, Mr. Whittemore, desired their final indorsement and to perfect the wording of the report, it was provisionally accepted and referred back to the Committee.

A nominating Committee was then appointed. It was ordered that hereafter all committee reports must be delivered to the Secretary at least 60 days before the Convention.

Papers on the Kansas City Water Works, by G. W. Pearson, and on River Improvements on the Atlantic Coast, by Colonel W. P. Craighill, were read. In the afternoon there was a reception given by resident members of the Society.

On June 30 most of the members visited the Milwaukee Water Works and other points of interest. At the regular session a number of papers and discussions were read, including that on High Masonry Dams, by Mr. J. B. Francis.

In the afternoon the members visited a number of manufacturing establishments, including the Chicago, Milwaukee & St. Paul repair shops ; the Milwaukee Cement Works ; and the Reliance Works of E. P. Allis & Company.

At the session on Monday, July 2, Professor J. B. Johnson, of St. Louis, explained his arrangement for elaborate tests of wooden beams, for which a special machine is to be constructed. The reading of papers and written discussions was continued ; the pressure of business was so great, however, that a large part of the papers had to be read by title only.

The Secretary then read a report on the Building Fund, stated the Society's condition, prospects, and the scope of its custodianship of records, valuable papers, etc., and appealed for private and corporation subscriptions for the $110,000 necessary to make up the $140,000 desired to build a plain fire-proof house for the use of the Society and the safe-keeping of its property.

The usual resolutions of thanks, etc., were passed, and the Convention adjourned.

The afternoon was spent in visiting points of interest about the city, and in the evening the annual banquet was held, over 200 persons being present.

On July 4 most of the members took a special train to the Springs at Oconomowoc and Waukesha, whence most of them returned to Milwaukee and started for home, a few, however, visiting Sault Ste. Marie.

American Society of Mechanical Engineers.

A RECENT circular from the Secretary, Mr. F. R. Hutton, contains the following preliminary announcement for the eighteenth convention of the Society, which will also be the ninth annual meeting.

"The Council have accepted the most cordial invitation of the Board of Trade of the city of Scranton, Pa., to hold its meeting in that city, beginning Monday evening, October 15, and a later circular will give the details of sessions, excursions, etc. The meeting comes somewhat earlier this year than usual, in order that the hill country of Pennsylvania may be enjoyed to the best advantage, and the meeting has been assigned, under the rules, for this date, with that object in view.

"The Society has so generally indorsed the plan of having all its papers in print and distributed in advance to those who expect to attend the meeting, that the attention of those who intend to be authors at this coming meeting is especially drawn to the necessity of having their papers, with illustrations, etc., complete, in the hands of the Publication Committee not later than August 20, 1888.

"The Secretary would solicit papers giving short accounts of engineering experiences, and also papers for the economic section of the Society's work on topics related to shop orders, methods of accounting, of superintendence, and management, and particularly of ascertaining cost of work.

"The Society's system of presenting and discussing papers enables it to handle exhaustively a large number of papers at a convention, and the privilege and duty of contributing in this way to the Society's work is urged on every one, even if he cannot expect to attend the meeting in person."

Association of Railway Telegraph Superintendents.

THE seventh annual meeting was held at the Murray Hill Hotel, New York City, on Wednesday, July 11, President Lang in the chair.

A number of new members were elected. After the reading and acceptance of the report of the Secretary and Treasurer, Mr. Bogart, from the Committee appointed last year to examine the various devices used for recording the signals transmitted over telegraph wires, made a verbal report. He had examined the self-starting registers manufactured by different establishments, and those of the Western Electric Company would be included in the exhibit of that company, which, with many others, would be ready for inspection Thursday morning. It was the intention to have the register operated by an electric motor in lieu of a spring or weight. An address was made by Commander A. D. Brown, of the United States Naval Observatory, on the Methods of Transmitting Correct Time. This was followed by an interesting discussion of the time question.

On Thursday the Committee reported upon the adoption of a substitute for the long dash now used as the character for the cipher. Mr. Selden reported in behalf of the Committee that a feeling existed among all people identified with telegraphy that they should not make any change in the Morse alphabet.

The following officers were elected for the ensuing year :

G. C. Kinsman, Decatur, Ill., President ; C. A. Darlton, Washington, Vice-President ; P. W. Drew, Chicago, Secretary and Treasurer.

The Committee appointed to fix the time and place of the next meeting reported in favor of holding it at Atlanta, Ga., on the third Wednesday in October, 1889.

The following resolutions were adopted :

"*Resolved*, That the Chair appoint a committee of five on electrical information, whose duty it shall be to disseminate matters brought to their attention by members of this Association.

"*Resolved*, That the Chair appoint a committee of three who shall select subjects and writers, said papers to be read at the annual meetings."

A paper on Electric Welding was presented by G. L. Lang, Mr. F. E. Kinsman also read a paper on an Electric Automatic Brake-Controlling Device.

The meeting then went into executive session and subsequently adjourned.

On Friday the members inspected the signals on the West Shore road at Weehawken, and also visited Manhattan Beach.

OBITUARY.

SAMUEL STILLWELL DOUGHTY, who died at Mount Kisco, N. Y., July 9, aged 77 years, was formerly an engineer and surveyor well known in New York City. He was for a number of years engaged in laying out the upper part of the city, and was also employed in the preliminary work on Central Park. He retired from business some years ago.

JAMES HARRIS, who died in St. John, N. B., July 6, aged 85 years, was born in Annapolis, N. S., but removed to St. John when a young man. In 1831 he started the establishment which has since developed into the extensive foundry, rolling-mill, and car-shops now operated by the firm of James Harris & Company. Mr. Harris was a man of strict integrity and great energy ; in spite of his great age he continued to work until a short time before his death.

ROBERT HALE died in Minneapolis, Minn., June 28, from injuries resulting from a fall ; he was 73 years old. Mr. Hale began his work in Vermont, and was, when still a young man, Superintendent of the Connecticut & Passumpsic Rivers road. Later he held similar positions on the Vermont & Massachusetts and the Boston & Albany railroads. In 1864 he was made General Superintendent of the Chicago & Alton, and held that office for seven years. He was then for three years General Superintendent of the Missouri Pacific, and on leaving that road settled in Minneapolis, where he was engaged in manufacturing. He always retained a lively interest in railroad matters. For four years past Mr. Hale had been Secretary of the Minneapolis Board of Trade.

HIRAM SIBLEY, who died in Rochester, N. Y., July 14, aged 81 years, was born in North Adams, Mass., and settled in Rochester when a young man. He was a man of active mind and keen foresight, and was one of the first to grasp the possibilities of the telegraph. In 1851 he bought the House patents and organized a company which soon owned many miles of wire. In 1856 he united his interests with those of the late Ezra Cornell, then head of a rival company, the result being the organization of the Western Union Telegraph Company. To Mr. Sibley's energy and persistence was mainly due the building of the first telegraph line through to the Pacific Coast, which was finished in 1861.

Mr. Sibley's next scheme was the construction of an overland telegraph line to Russia, and he devoted a great deal of time and energy to it. Surveys were made, and the line was built as far as Skeena River, in Alaska, when the successful laying of the second Atlantic cable put an end to the enterprise, and it was abandoned. In 1866 Mr. Sibley was forced by ill-health to give up the Presidency of the Western Union Company, which he had held since the formation of the company, and went to Europe for a complete rest. In 1869, his connection with the company terminated when he resigned the Vice-Presidency. He then sold out his telegraph interests and went into the seed business in Rochester and Chicago on an extensive scale.

Mr. Sibley has been a generous donor to the Rochester University and to the city, Sibley Hall having been built by him at a cost of over $100,000, and a library and other gifts are among his benefactions. The Sibley College of Mechanical Arts of Cornell University is the result of his old friendship for Ezra Cornell in the early days of telegraphy. He has been in feeble health for some time, owing to his advanced age.

PERSONALS.

WEBSTER SNYDER has resigned his position as General Manager and Chief Engineer of the Gulf, Colorado & Santa Fé Railroad.

L. B. PAXSON is now Acting Superintendent of Motive Power and Rolling Equipment of the Philadelphia & Reading Railroad, succeeding G. W. Cushing, resigned.

A. H. SMITH has been appointed Mechanical Superintendent of the Northern and Southwestern districts of the Grand Trunk Railway, with office in Toronto, Ont.

PETER CLARKE has been appointed Mechanical Superintendent of the Kingston-Toronto District of the Grand Trunk Railway.

J. W. AYER, of Kansas City, Mo., is Chief Engineer of the projected Kansas City & Sabine Pass Railroad.

JOHN HORNBY has been appointed General Superintendent of the Fort Worth & Rio Grande Railroad, with office at Fort Worth, Tex. He was formerly connected with the Marquette, Houghton & Ontonagon road.

SAMUEL REA, late Principal Assistant Engineer of Construction, has been appointed Assistant to the Second Vice-President of the Pennsylvania Railroad Company.

H. B. LA RUE, who for twelve years past has represented the Midvale Steel Company of Philadelphia, will sever his connection with that company on August 15. Mr. La Rue will take a well-earned rest, and will then take up a new line of work.

R. A. BACON has been appointed Superintendent of the Rome & Decatur Railroad. Major Bacon was until recently Secretary of the Georgia Railroad Commission.

H. G. RAWORTH, of Aiken, S. C., has claims to be considered the oldest living locomotive engineer. He entered the employ of the South Carolina Railroad Company as an apprentice in the shops in 1829, and in 1834 took charge of a locomotive on the road. He continued to run regularly until a short time ago. Mr. Raworth is now 77 years old, and is in excellent health.

H. J. SMALL has resigned his position as Assistant Superintendent of Motive Power of the Philadelphia & Reading Railroad, and will go to a California road.

J. L. GREATSINGER has been appointed Master Mechanic of the Duluth & Iron Range Railroad.

BRIGADIER-GENERAL JAMES C. DUANE, Chief of Engineers, U.S.A., has been placed on the retired list, having reached the age prescribed by law as the limit of active service.

COLONEL THOMAS LINCOLN CASEY has been appointed Chief of Engineers, U.S.A., in place of General Duane, retired. He is the son of General Silas Casey, U.S.A., and was born in 1833. In 1852 he was graduated first in his class at the United States Military Academy and assigned to the Corps of Engineers. From 1854 to 1859 he served as Assistant Professor of practical, civil, and military engineering at the Academy. During the War he was employed on engineer duty, at first in the West and afterward in the East. He was on special duty at the attack on Fort Fisher in 1864, and for services on that occasion was brevetted, and later received the brevets of colonel and lieutenant-colonel for faithful service during the war. For ten years, from 1867 to 1877, he was in charge of the division of fortifications in the Engineer Department at Washington, and was then placed in charge of public buildings. Under his supervision several important structures were reared. In 1868 he was sent to Europe to examine the torpedo system of foreign nations. Ten years later he undertook the completion of the Washington Monument, which he effected in 1884.

NOTES AND NEWS.

Electric Lighting of New York Harbor.—Arrangements for the illumination of Gedney's Channel, New York Harbor, have been perfected, and it is expected that contracts for the work will be made shortly. Six electric light buoys will be used, three on each side of the channel. They will be placed 1,100 ft. apart, and are expected to light the channel so that

vessels can enter the harbor at night as safely as in the daytime. The establishment of these lights will cost about $26,000, and they can by maintained at a cost of $3,000 a year.

An Unlimited Pass.—In 1836, when the Boston & Providence Railroad Company was chartered, Mr. John C. Dodge, of Attleboro, conveyed a portion of his land in consideration that he and his family should ride free over the railroad as long as the land was used for railroad purposes. A grand-daughter of Mr. Dodge claims that she is entitled to the privilege named in the deed, and that the word family meant "descendants" of the grantor. The railroad company demurred on the ground that the remedy of the plaintiff is at law and not in equity. Judge Allen overruled the demurrer, and expressed an opinion that under the deed the Boston & Providence Railroad Company would be required to carry free the descendants of Mr. Dodge for all time.

The New Naval Observatory.—The contract for the new buildings for the Naval Observatory has been awarded by the Secretary of the Navy to P. H. McLaughlin & Co., of Washington, the contract price being $307,811. This does not include the piers and domes, which will be built by experts under the supervision of the officers in charge of the Observatory. The new buildings will be on Georgetown Heights, near Washington, and will include the main building; the equatorial building, where the great telescope will be mounted; the clock-room, where the observatory clock will be set up and chronometers kept and regulated; two transit buildings; two observers' rooms; a boiler-house and engine-room. The buildings will be of Tuckahoe marble; they are to be begun at once and finished in 18 months.

The Trans-Caspian Railroad.—The Russians having opened their railroad from the Caspian to Samarcand are now busy discussing two proposals—one for extending her Rostoff-Vladikavkaz Railroad to Petrovsk, on the Caspian Sea, and another for pushing down to the same point the railroad system from Tzaritzin. In either case the European net-work would then be complete without break of any kind, to the Caucasus shore of the Caspian Sea; and the only water intervals between London and Samarcand would be the bit between Dover and Calais and the 16 hours' run by steamer between Petrovsk and Azoun Ada. With regard to completing the railroad system to the Caspian itself, the question now is upon the carpet, and we may expect to see the line commenced in a very short time.

A Swedish Ship Canal.—The Orebro Canal, in Sweden, an undertaking of considerable importance, will prove a great boon to the town of Orebro. Its object is to bring vessels from the Malar and Hjelmar lakes into the center of the town, whereas they have hitherto been only able to get within a mile or so of the town. Mr. W. Johansson is the Chief Engineer of the canal, and the work which was commenced in June, 1886, has been well carried out. The main canal has a breadth of 80 ft. to 90 ft. at a water line, and expands at the end into a basin of 150 ft. in breadth, with a high granite quay 1,211 ft. long. The granite quay on the northern branch of the canal has a length of 400 ft.; the canal is here 150 ft. broad. From this quay the vessels can pass into the water of the main canal through a swing bridge of iron, manufactured by the Arbogo Engineering Company.

Underground Railroad for Chicago.—Recently a company was incorporated to build an underground railroad for Chicago and the surrounding country. The company is limited by its articles of incorporation to a capital stock of $27,000,000. The incorporators are Chesley R. Crumpton, L. H. Clarke, George W. Wilson, George W. Waite, L. M. Nelson, Frank McMaster, James A. Slanker, and George H. Waite. The plan of the road contemplates digging a tunnel of sufficient capacity to admit of a double-track road, with shafts or stations every quarter of a mile, and the necessary elevators to handle passengers and freight business. The tunnel is to be lighted and drained, and to be built so far below the surface as to go beneath the sewers and water-tunnels. Among other things the company proposes to furnish connections for shifting freight between the various railroads reaching Chicago.

English Fast Trains.—The distance from London to Manchester by the Midland or by the London & Northwestern road is 184 miles, and by the Great Northern it is 203 miles. The fastest trains on all three of the roads make the trip in the same time (4¼ hours) making an average speed for the Great Northern train of 47.8 miles per hour, and on the other roads of 43.3 miles per hour. The three roads together run 23 trains each way which make the distance in less than five hours.

A recent change in time-table has shortened the running time made by the Great Northern Railroad in England between London and Edinburgh; the distance is 396 miles and the train goes through in 8½ hours. Deducting the necessary allowance for stops, the average speed of this train is 49.6 miles per hour, which is about 2½ miles more than was previously made. The fastest time made by this train is over the section from York to Newcastle; the time allowed for the distance is 83½ miles in 97 minutes, an average speed of 51.6 miles per hour.

Russian Forests.—The Russian Government has at length taken measures against the destruction of the forests in the empire, which has gone on in all directions and has brought about climatic changes in the country, one of the most serious results being the shallowing of several harbors, ports, and large water-courses. The measures for carrying the foregoing into effect are intrusted to a commission with plans not only for the preservation of standing timber, but for the planting of saplings and the proper and regular thinning of forests. With regard to private woods, the measures issued by the Commission are to be applied with the consent and co-operation of the proprietors if possible. If the latter are opposed to such measures the property is purchased by the State at a certain valuation, and the necessary plans are carried out. The owners have a right within a certain period of repurchasing the property for the same price, but with the addition of the cost of introducing the measures and 6 per cent. per annum on the capital. In other cases the necessary steps can be taken without purchasing the property at the expense of the proprietor.

The Largest Electric Light in the World.—The English light-house authorities have recently placed what is claimed to be the most powerful electric light in the world in the new light-house at St. Catherine's, the southernmost point on the Isle of Wight. It is an incandescent light of 60,000 candle power, the carbon points used being no less than 60 millimeters, or nearly 2½ in. in diameter. The lamp is of the Serren-Berjot type, and, as the light-house is what is known as a rotating light, the whole apparatus is revolved by a small vertical engine, worked by compressed air, the speed being regulated automatically. The power is furnished by three engines, each of 12 nominal H.P., and capable of working up to 48 H.P., should occasion require. Usually only one of these engines is in use at a time although two or three of them can be put on; the intention is to keep one in reserve in case of accident. There are two dynamos, only one of which is used at a time. It is calculated that, if the whole power of the engines and dynamos are brought into use at the same time and concentrated, the light from the lantern will equal 6,000,000 candle power.

Non-Corrosive Propeller Blades.—As is well known an important question which marine engineers have been considering for some time is the discovery of an alloy which will resist the corroding and pitting to which cast-steel propeller blades are liable. The cost of bronze, phosphor-bronze, and other compositions is so high that the use of steel presents great advantages. At the recent meeting of the English Institution of Naval Architects a paper was read by John Willis, of Attercliffe, who claims to have discovered a method of preventing corrosion. His invention consists of a coating of copper united to a steel casting. The copper plate is bent into proper shape and is then placed in the mould, into which the iron or steel is poured, the result being that the copper is firmly united by fusion to the steel face. Other anti-corrosive metals can be used in place of copper. It is claimed that there is a perfect joint and that corrosion will be entirely prevented, while the cost will be very little above that of a plain cast-steel propeller. Mr. Willis's method is covered by a patent which he has obtained in England.

Limited Stock Companies in Mexico.—The law of April 7, published in the *Diario Oficial* of April 10, 1888, fixing the status and responsibility of stock companies in Mexico, is of special importance to those Americans who may now have or hereafter establish such companies in this country. The principal provisions are that the title must simply state the particular line of business for which they exist. For example, the Mexican Central Railway Company or the Mexican Fiber Company are *Sociedades Anónimas* within the meaning of the law. If the name of any shareholder appears in the title of the company he becomes personally responsible therefor. In an anonymous company the liability is strictly limited. Such a company may be organized in two ways; first, by public subscription; second, by two or more persons signing the articles before a notary. In the first sort the following are requisites:

1. The publication of the prospectus.
2. The subscription of the capital.
3. A general meeting to approve and ratify the constitution.
4. The notarial registration.

No company is legally constituted until the capital stock is fully subscribed and 10 per cent. paid in cash.—*Report of Consul-General Sutton to State Department.*

Age of Locomotives in Germany.—Herr Leonhardt, a German engineer, who has been investigating the subject, says that the number of locomotives in use on German railroads at the end of the railroad year 1885–86 was 12,450. The average age of the locomotives in use during the year of service 1884–85, was 12.60 years; and in 1885–86, 12.49 years. This is deduced from a table of the number of engines added and in active use for each year from 1843 to 1885. From this table it follows that 59 engines built prior to the year 1850 were running during the year 1885–86, and that the distinction of being the oldest running engine in Germany falls to one on the Holsteinische Marschbahn, which dates back to 1845. An examination of the table shows also that the average number of engines still extant is under 100 for each year prior to 1857; from 1858 onward the number rises steadily. Thus, in the year 1885–86, there were still 210 locomotives which began work in 1864. In the next few years the increase in numbers is still more rapid, and reaches in 1874 a maximum of 1,478 for the year 1884–85, and 1,464 for the year 1885–86. From 1878 until 1880 there is a steady decrease, which attains the minimum in the latter year. There are 131 engines of 1880 in 1884–85, and 132 engines of 1880 in 1885–86. The subsequent numbers again rise to over 500 for 1883; thus there were 517 engines which began work in 1883 in use during 1885–86.

Japanese Lacquer for Iron Ships.—The Japanese Admiralty has finally decided upon coating the bottoms of all their ships with a material closely akin to the lacquer to which we are so much accustomed as a speciality of Japanese furniture work. Although the preparation differs somewhat from that commonly known as Japanese lacquer, the base of it is the same—viz., gum-lac, as it is commonly termed. Experiments, which have been long continued by the Imperial Naval Department, have resulted in affording proof that the new coating material remains fully efficient for three years, and the report on the subject demonstrates that, although the first cost of the material is three times the amount of that hitherto employed, the number of dockings required will be reduced by its use to the proportion of one to six. A vessel of the Russian Pacific fleet has already been coated with the new preparation, which, the authorities say, completely withstands the fouling influences so common in tropical waters. It took the native inventor many years to overcome the tendency of the lac to harden and crack; but having successfully accomplished this, the finely-polished surface of the mixture resists in an almost perfect degree the liability of barnacles to adhere or weeds to grow, while, presumably, the same high polish must materially reduce the skin friction which is so important an element affecting the speed of iron ships. The dealers in gum-lac express the fear lest the demand likely to follow on this novel application of it may rapidly exhaust existing sources of supply.—*The London Engineer.*

Russian Railroads.—From a report just issued by General Possiet, Russian Minister of Ways of Communication, we gather that, at the beginning of the present year, there were 27,723 versts, or nearly 18,500 miles of railroad open for traffic in Russia, including the railroad system of Finland—a little over 1,000 miles—and that of the Trans-Caspian territory, 660 miles. The latter is described as a purely military line. In Finland the whole of the railroad system, except 20 miles, has been constructed by the Government. Of the general mileage of Russia, 5,488 versts belong to the State, and 20,785 to various companies, most of whom, however, are subsidized by the State, and more or less under Government control. The revenue last year on all the lines amounted to $122,000,000, of which $9,985,000 was derived from the State railroads. The increase was $13,810,000, or $11\frac{1}{2}$ per cent. over 1886. The best paying line was the Nikolaevsky, running from St. Petersburg to Moscow, which yielded 36,675 roubles per verst; the Moscow-Riazan followed with 30,029 roubles, the Riazan-Kozloff with 28,727 roubles, and the Warsaw-Vienna with 25,664 roubles. The Borovitchisk line yielded only 1,746 roubles per verst, and the strategical railroad through the Pinsk Marshes 1,376 roubles. The total number of passengers conveyed throughout the year was 34,757,923 civilians and 2,426,850 soldiers. The freight traffic amounted to 50,000,000 tons forwarded by slow trains and 160,000 tons by fast ones. In general, the year was a favorable one for the railroads; but, owing to the lowness of the exchange and the compulsory payment of many of the railroad loans abroad in cash, the financial results were, so far as the State was concerned, worse than usual.

Old Brass Tickets.—Mr. C. E. Stretton writes to the English *Mechanic* as follows: "The annexed illustration is a full-sized representation of the old brass railway tickets used on the Leicester & Swannington Railway from the opening of the line, July 17, 1832, to 1846, when it became the property of the Midland Company. If a passenger were going from any station—for instance, to Bagworth, perhaps—ticket No. 20 would be

issued to him, and this number and the amount of fare paid would be duly recorded in a book.

"The guard of the train carried a leather bag, somewhat in the form of a collecting-box, having a separate division for each station, into which the tickets were placed by the guard when collected, and returned to the station from whence they were issued, to be again used.

"These tickets appear to be such interesting relics of early railways, that I have lately presented one of them to the South Kensington Museum."

Railroads in the Philippine Islands.—Two projects to construct railroads on the island of Luzon, of the Philippine Archipelago, have been authorized by royal decree of the Spanish Government. The first is under a grant from the Government to an English firm in Liverpool represented in Manila by the firm of Smith, Bell & Company. It is proposed to build a line, 18 miles long from Manila to Antipolo, where a religious festival is held once a year, which is attended by a number of pilgrims. A large revenue from the passenger traffic is expected during the festival.

The second project is more important. It is that of a corporation called "The Manila Railway Company, Limited." The company is formed for the purpose of constructing and working a railroad starting from a point in the district of Tondo, Manila, and terminating at Dagupan on the bay of Lingayen, its length being about 120 miles. The line already surveyed runs through a very fertile and populous country, and it is confidently expected that it will do an exceedingly large freight business.

Petroleum Deposits in Venezuela.—That part of the department of Colon, in Venezuela, situated between the rivers Santa Anna, Zulia, and the Sierra of the Colombian frontier, is very rich in asphalt and petroleum. Near the Rio de Ore, and at the foot of the Sierra, there is a very curious phenomenon consisting of a horizontal cave, which constantly ejects, in the form of large globules, a thick bitumen. These globules explode at the mouth of the cave with a noise sufficient to be heard at a considerable distance, and the bitumen, forming a slow current, falls finally into a large deposit of the same substance near the river bank. For a long distance from the site of this phenomenon the ground is covered or impregnated with petroleum.

Considering the great amount of inflammable gases which must be given out by the flows and deposits of petroleum described above, it may be easily believed that this has a direct bearing upon the phenomenon known since the Conquest as the "Faro" of Maracaibo. This consists of constant lightning without explosion, which may be observed toward the southward from the bar.

The State of Zulia, in which are situated all the deposits of coal, asphalt, and petroleum, is as yet free from any monopolistic concession; but this cannot last forever, and it remains to be seen whether American enterprise and capital will eventually take in hand the development of a most profitable industry.

The New English Magazine Rifle.—The following particulars connected with the proposed new magazine arm will

doubtless be interesting to many. The bore is 0.303 in. diameter, giving about 33 per cent. more rounds than the Martini-Henry for the same weight of ammunition. It has a detachable magazine. Experiments with the troops at Shorncliffe with the Martini-Henry, with a rifle with a fixed magazine, and also one with a detachable magazine, have shown that the last has a great advantage, arising from the circumstance that when a magazine is empty another filled magazine can be put in its place in the same time that it takes to get a cartridge out of the pouch and load with it. Thus the soldier is able to keep his attention directed almost wholly to the object at which he is firing, so long as his supply of magazines lasts. In a fixed magazine the advantage of rapidity is confined to the number of rounds supplied by the single magazine. When they are discharged, the rifle is simply a breech-loader, until a suitable opportunity arises for recharging the magazine, unless some special charging gear is applied which approaches in degree the conditions of a detachable magazine. One magazine is attached by a chain to the rifle, so as to secure its retention. Subsequent magazines may be discharged and thrown away, if necessary, in the full heat of action, for in the continued use of magazines we are contemplating a time of supreme stress and importance. The attached magazine contains eight rounds, those subsequently used six rounds each. At present the infantry soldier will carry one or two spare magazines; thus, with the first one, he is furnished with a reserve of 14 or 20 rounds for rapid discharge, according to whether he has one or two spare magazines. Cavalry and mounted infantry could carry bandoliers with eight or ten detachable magazines. Sergeant Beckwith, of the Tenth Hussars, carried eight magazines in his bandolier during the experiments. Mounted infantry thus become specially formidable, for it may be noticed that, both as to carriage power and the object of despatching them to produce a rapid, telling blow, magazines in bandoliers are admirably adapted to their case. Three hundred and fifty rifles are ready for the troops. The Rubin cartridge is to be used experimentally, but English ammunition is progressing, and will, it is hoped, be ready when the experiments are over. —*The London Engineer.*

Fuel-Testing Stations.—A writer in *Nature*, Mr. Bryan Donkin, Jr., proposes the establishment in London of a station of this kind, of which there are now a number in operation on the Continent. He says:

"So far as I know, there does not exist anything of the kind in England where, as on the Continent, coals can be tested for their evaporative power, the gases of combustion analyzed, and all the results carefully reported on by experts. It should, I consider, be placed on a perfectly independent footing, and managed by experts, under a small committee appointed by those who assist with money or otherwise. It might follow generally the lines of existing coal-testing stations, but with all modern improvements.

"In this country (England) it is remarkable that neither the sellers of coal take the trouble to find out how much heat they are offering, nor the purchasers how much they are getting for their money, and this notwithstanding the hundreds of millions of tons of coal changing hands yearly. Colliery-owners and coal-merchants, as well as the large consumers, know very little about coal calorimeters, although the former sell so much heat, and the latter try to utilize it to the best advantage. How few of the latter weigh their coal regularly, or keep any weekly record of the quantities of ashes and clinkers, to find out how much dirt and incombustible matter they are paying for! How few know what it costs them in fuel to evaporate one thousand gallons of water into steam, which is one of the best standards of comparison in a given district!

"The station would require to be advertised and made known in various ways. Colliery-owners would no doubt find it to their advantage to have their different kinds of coal tested and reported upon, so as to offer them to their customers with their ascertained heating value or evaporative power. Large consumers of coal (railway companies, water-works, and others) should know the heating value of the coal they are paying for, and the percentage of incombustibles."

What is said of England is equally true of this country. With the great variety of coals in this country it would seem as though it would be profitable to have some reliable authority to determine their values.

The correspondent mentions the following experimental fuel-testing stations on the Continent:

"The Imperial Naval Administration Coal-Testing Station at Wilhelmshaven, Germany, was established in 1877.

"Dr. Bunte's coal-testing station, erected at Munich about 1878, particulars of which have been published in the *Proceedings* of the Institution of Civil Engineers, vol. lxxiii. Here some hundreds of trials have been reported on and published; much valuable work has been done, and many fuels tested, including coals of the Ruhr Valley, Saar Basin, Saxon and Bohemian coal-fields, and those of Silesia and Upper Bavaria. The boiler of the station has about 450 square feet of heating surface. The gases and coals are analyzed, and all particulars carefully noted. It is one of the most complete stations I have seen.

"In Belgium, near Brussels, there is a Government station for testing fuels, under the administration of the Belgian State railways; locomotive boilers are used. The establishment has been at work for the last two years, but no results are published, as they are considered the property of the Government. Private firms can, however, have their coals tested and reported upon.

"The Imperial Marine Station, Dantzig.

"Boiler Insurance Company at Magdeburg."

Foreign Naval Notes.—The ironclad *Emperor Nicholas* ready to be launched on the Neva for the Russian Baltic Fleet, is of 8,500 tons, 330 ft. long, 63 ft. broad, and 21 ft. deep, furnished with engines of 8,000 indicated H.P., steaming at 16 knots. The armor plating of the vessel is 10 in. thick, and she will carry eight 8-in. and ten 6-in. guns. The *Pamiatz Azova*, a cruiser of 6,000 tons displacement, 354 ft. long, 49 ft. broad, and 23 ft. deep, intended for the Pacific service is also just ready. Her engines are of 8,500 indicated H.P., steaming at 17 knots. She is protected at places with from 8 in. to 10 in. of armor plating, and her armament comprises two 8-in. guns and four 6-in. Both vessels are being built at private yards.

Four new armored-deck ships of the *Dogali* type are to be laid down at once for the Italian Navy. The *Dogali* is a torpedo ram cruiser, with a deck armor 150 millimeters thick, and of 2,050 tons displacement, and is fitted with engines of 7,500 H.P., which have propelled the vessel at a speed of 20 knots. She is armed with six 15-centimeter guns and 15 mitrailleuses. Four new torpedo cruisers of the *Tripoli* class are also to be built. They will have deck armor 25 millimeters thick, a displacement of 741 tons, and three engines of 4 200 H.P., working three screws, which will give them a maximum speed of 23 knots. These screws are three-bladed, and two of them are placed at the same height at the base angles, the third screw at the acute angle of a triangle directed with its point downward. Italian naval officers consider this arrangement very efficient, not only for the attainment of a high speed but also for maneuvering vessels. The four vessels will be armed with eight quick-firing guns and three mitrailleuses. It has been further decided to build five torpedo avisos of the *Folgore* type, intended for the pursuit of torpedo boats. They will have, like her, a displacement of 317 tons, engines of 2 800 H.P., a speed of 20 knots and be armed with two quick-firing guns and four mitrailleuses. A large number of sea-going torpedo boats are also to be constructed immediately. The Government dockyard at Castellamare is at present engaged on the construction of a vessel each of the *Dogali*, *Tripoli*, and *Folgore* type, respectively.

An article in *Les Annales Industrielles* gives the following list of cruisers in the French Navy:

Broadside cruisers, seven; three are of iron and run 17 knots an hour. The *Duquesne* and the *Tourville* are 12 years old; the *Sfax* alone is a modern ship. The rest are of wood, and, therefore, they do not fulfill in any respect the conditions of the war of the future. The *Iphigénie* and the *Naïade* are old-fashioned.

First-class cruisers, nine; all are of wood except the *Duguay-Trouin*, and run from 14 to 15 knots.

Second-class cruisers, ten, all of wood, with widely-differing capabilities; not one of them could run 15 knots on service. We must not omit, however, the *Milan*, of steel, which runs 18 knots, but which is only a dispatch vessel with limited action.

Third-class cruisers, nine, all of wood, of no great value. They are being struck off the list annually.

Torpedo catchers, three. The *Condor*, the *Epervier*, and the *Faucon* are afloat, running 18 knots. Sphere of action very limited. It is useless to class the wooden-dispatch boats.

In addition to these there are now in the dockyards, or just launched, the following ships:

Broadside cruisers, three. The *Dupuy-de-Lôme*, of 6,300 tons; the *Cecille*, 5,766; the *Tage*, 7,045; the two last are launched, and ought to run about 20 knots. The *Dupuy-de-Lôme* will be completely armored, but it is hardly commenced, and judging by the pace at which constructions progress in France, it may be predicted that it will not be armed before the end of 1891.

First-class cruisers, three, of 4,160 tons and 19 knots speed; second-class cruisers, two, of 3,025 tons and 20 knots speed; third-class cruisers, six, of 1,850 tons and 19 knots speed. There are also one torpedo catcher and three dispatch boats.

THE RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

PUBLISHED MONTHLY AT No. 45 BROADWAY, NEW YORK.

M. N. FORNEY, ... Editor and Proprietor.
FREDERICK HOBART. . . . . Associate Editor.

Entered at the Post Office at New York City as Second-Class Mail Matter.

SUBSCRIPTION RATES.

Subscription, per annum, Postage prepaid	$3 00
Subscription, per annum, Foreign Countries	3 50
Single copies	25

Remittances should be made by Express Money-Order, Draft, P. O. Money-Order or Registered Letter.

MR. J. HOWARD BARNARD, 7 Montgomery Avenue, San Francisco, Cal., is the authorized Western Agent for the JOURNAL.

MR. FREDERIC ALGAR, Nos. 11 and 12 Clements Lane, Lombard Street, London, E. C., England, is the authorized European Agent for the JOURNAL.

NEW YORK, SEPTEMBER, 1888.

NEW YORK is just now fortunate in having a Mayor whose "eccentricities" are looked at by the politicians with alarm and disgust, but by the people with very hearty approval. One of these "eccentricities" has been the appointment of four new commissioners to take charge of the new Croton Aqueduct, who are, contrary to all precedent, probably four of the best men in the city who could be picked out for that purpose. Their number includes an engineer of national reputation and three well-known citizens, respectively a builder, a lawyer, and a business man, who are actually almost unheard of in city politics, and have been known only on account of their honesty, public spirit, and ability in conducting their own business. Under their charge it is altogether probable that this great engineering work, which is to complete the arrangements for New York's water supply, will be finished as it should be, and that the new Croton Aqueduct will be hereafter a credit to the city instead of becoming, as it threatened to be, a public scandal. A few more officers as "eccentric" as Mayor Hewitt would be welcomed in the public service, not only in New York, but elsewhere.

THE retirement of General James C. Duane as Chief of Engineers, under the age limitation provided by law, again suggests doubt as to the wisdom of such a regulation, especially in the staff departments of the Army, where long experience is of quite as much, if not more, value than ability to perform active service in the field. In this case General Duane is retired while at the height of his usefulness, and while in all human probability there still remains a number of years during which he would be able to do most excellent service. The duties of the Chief of Engineers are, after all, more in the nature of those of a consulting engineer, and he is not called upon to do the hard work or to undergo the exposure to which subordinate members of the corps are occasionally subjected. That General Duane is still capable of doing excellent work is evidenced by the fact that his appointment to a position where he will probably have entire supervision of the completion of the new Croton Aqueduct meets with universal approval.

THE Canadian Pacific is to lose its monopoly of business in Manitoba, and is to meet with active competition there from the Northern Pacific. The provincial authorities have made arrangements with the latter company to operate a line from Winnipeg to the boundary, and it is expected also that a line will be built from Winnipeg westward to Portage-la-Prairie, Qu'Appelle and Brandon, with several branches to be added hereafter. This line will nearly parallel the Canadian Pacific through the most productive portion of its northwestern territory, and it will give the Northern Pacific access to nearly all the settled portion of that country. The Province not only authorizes the building of the road, but will give a subsidy of $5,000 a mile, with certain other advantages. The road will, of course, be built by a corporation organized in Canada, but under the Northern Pacific control. The American company will thus be in a position to retaliate locally in a great measure upon its Canadian rival for the competition on through business, which it has felt pretty severely, and there will be an opportunity for a very lively war.

THE last loan of the Panama Canal Company has proved a partial failure, only $56,000,000 out of $140,000,000 offered having been taken. *L'Economiste Française*, an eminent authority, states that out of the $56,000,000 subscribed, no less than $44,000,000 will be absorbed by the Government deposit required to guarantee the yearly drawings for redemption of loan, and by the immediate requirements of the company for interest, leaving only $12,000,000 available for the immediate continuance of the work, which is a sum altogether insufficient to secure any considerable progress. In the mean time, M. De Lesseps continues to promise the opening of the canal in 1890, in spite of the fact that it is now well known that this would be utterly impossible, even had the company abundance of means at its command. It is evident, indeed, that a crisis is fast approaching, and that a suspension of work, if not a total collapse of the company, is among the probabilities of the immediate future.

THE Russian Government has suspended, for the present, work on the further extension of its Transcaspian line, and is devoting some attention to the improvement of its connections westward. Two or three lines to ports on the Caspian Sea are now under examination, and the work of construction of one of them has already been begun, while a considerable amount is to be expended in and about the port which is the western terminus of the Transcaspian road itself. The eastward extension of the line has not, however, been abandoned by any means, and the work of building toward the Chinese frontier will be resumed in a few months.

AT the recent general meeting of the Metropolitan Railway Company in London, the President, Sir E. W. Watkin, announced that arrangements were in progress for testing an electric motor on one section of the line. This motor was to be prepared and put in operation by the

Electric Traction Company, which has already some of its engines running on one of the London street railroads. The conditions imposed by the Metropolitan Company are that the electric motor should work as economically, and should, speaking mechanically, have as long a life as an ordinary locomotive. It is expected that the test will begin in September.

The Metropolitan Company probably has a greater interest in this question of electric traction than any other railroad company in the world, as the proper ventilation of the underground line, and the disposition to be made of the steam and smoke from its locomotives, has been the most difficult matter it has had to contend with. The adoption of the electric motor would make the ventilation of the tunnels a comparatively easy matter, and the railroad would then be much more desirable for travelers.

As finally agreed on in conference between the Senate and the House, the Army Bill appropriates $700,000 for the equipment of the gun factory at the Watervliet Arsenal and $3,500,000 (instead of $5,000,000) for the purchase of steel forgings for guns. The expenditures, both for the forgings and for the gun factory, are to be made under the supervision of a board, which is to consist of the Chief of Ordnance, the Chief of Engineers, and an artillery officer to be designated by the Secretary of War.

It is understood that the Bureau of Construction in the Navy Department has under preparation plans for two vessels to be built under the appropriation for coast and harbor defense. These plans are not yet ready to be made public, but it is said that the ships are to be of the single-turreted *Monitor* type, of about 3,500 tons displacement, and are to carry in the turret one 16-in. gun, with one or two dynamite guns of large size mounted in the hold or under the decks. They are to have engines of the latest pattern, and are to be able to make at least 16 knots per hour. This speed will not have to be kept up for a long distance, as these ships are not intended for cruisers.

The present double-turreted ships of the *Monitor* type, which are now in process of completion, are of about 3,000 tons displacement, and are to be armed with four 10-in. guns (two in each turret), except the *Puritan*, which is to have somewhat heavier guns, and is of 3,900 tons displacement.

A 16-in. gun is a very formidable weapon, and how it will work on a comparatively light ship is not altogether certain. This gun and the two dynamite guns ought to make these ships dangerous antagonists to any vessel now afloat, and effective assistants to land defenses.

The design of these ships is original, and they will doubtless be sharply criticised by naval authorities. The publication of the plans will be looked for with much interest.

An example of the steamboat business done on the Upper Hudson—and of what might be done on the Lower Hudson with proper management—may be found in the fact that on Saturday, August 4, the *Mary Powell* carried 1,600 passengers on her afternoon trip up from New York. This was no special excursion, but only the regular trip which this boat makes, landing at half a dozen points along the river from West Point to Rondout.

HOW TO BECOME AN ENGINEER.

There are probably few engineers who do not from time to time receive letters somewhat like the following:

I have a son eighteen years of age who is anxious to obtain employment with some reliable person to study or learn the art of Civil Engineering. He is a smart, intelligent boy, and with proper training I think something could be made of him. I would esteem it a great favor if you could take him in hand, or perhaps you could introduce him to some parties in this section who would do so.

Those who have passed the half century meridian of life, where hopefulness begins to decline, probably finish reading such letters with a sympathetic sigh for the young aspirant who has the struggle, the weariness, and the disappointments of life still before him, and who, like all young people happily, has only a faint idea of the difficulties which stand in the way of success. Unfortunately, too, human beings, especially young ones, have only a limited capacity for profiting by the experience of others. Perhaps that, too, is as it should be, because characters are so unlike that the experience which would indicate to one person one course of action might lead another in quite a different direction.

About all that can be done, then, when those who are inexperienced ask for help, is to turn them so that they will face in the right direction, and then leave them to make their own careers, as all of us must do eventually at any rate.

Perhaps the first thing which needs to be said in reply to a letter like the one which has been quoted, is that the terms "Engineer" or "Civil Engineer" are very indefinite, and evidently the correspondent quoted has a very vague idea of the profession or occupation which his son wishes to enter. Perhaps the best service which could be rendered to this correspondent would be to mark out with red ink—for emphasis—the words *engineer* and *engineering*, where they occur in his letter, and request him to substitute some other and more definite terms. This might lead him to inquire, and such inquiry would reveal that the terms engineer and engineering are generic, and include a great variety of occupations which demand an almost equal diversity of qualifications for their successful conduct. The term *engineer* is not more definite than "merchant" is. If some one had written to our correspondent that he had a son who was anxious to become a merchant, the natural question would be, What does the young man want to sell? It is just as essential, before a person engages in the occupation of an engineer, that he should know what he will make, as it would be if he entered mercantile life that he should determine what he will sell.

But, unfortunately, mankind—and more especially womankind—have a great propensity to euphemism—that is, to disguising common things with fine names. There is an enterprising dealer in fish in New York who announces himself as an importer of "sea food." Another firm announce that they are dealers in "Products of the Levant, Orient and Mediterranean." Just what the latter have for sale we have no means of knowing, but raisins, rugs, and rags are products of the regions named, and perhaps are included in the articles they buy and sell. Now, not many young men who think they are entitled to social distinction—or their mothers either—would like to announce that they or their sons had gone into the old rag business, although

they might be quite willing to have it announced that they had accepted a position in the office of a firm who are importers of the " products of the Orient." In the same way the euphemism of the term " engineer," and especially " civil engineer," attracts many young persons to the various occupations to which those fine-sounding terms are applied. As a matter of fact, the occupation or the " profession"—if it is regarded as such—of a " civil engineer," as it was practised fifty years ago, has, by processes of integration and differentiation, almost ceased to exist. Then a civil engineer was a person whose scientific training and experience was supposed to qualify him to undertake the construction of any structure or mechanism required. He located railroads and canals, superintended their construction, designed the bridges and machinery, and had charge of all the construction on the line. Now everything has become specialized. The location is intrusted to one man, and he or his class, more than any others, seem to have clung to the title of " civil engineer" up to the present time. Few locating engineers, however, now design bridges. Wooden, metal, and stone bridges are each specialties, and the persons who undertake the construction of one kind seldom take up any other. The same is true of turn-tables, water-supply structures, switches, signals, stations, locomotives, cars, etc., etc. Not only is this the case, but the different parts of cars and locomotives have become specialties. Wheels, springs, axles, brakes, car-seats, ventilators, injectors, lubricators, headlights, steam gauges, safety-valves, and many other parts are made by firms and companies which devote their time and attention exclusively to their manufacture.

The same thing is true of all branches of engineering. In marine work, stationary engines, electrical machinery, tools, agricultural implements, and so on indefinitely, the occupations of those who make these structures is daily and yearly becoming more and more specialized. There are, it is true, some men still needed to locate railroads, to construct water-works, docks, and improve our water-ways, but these occupations are also becoming specialties.

It is, therefore, of the utmost importance that when a young man or his parents determine that he should become an " engineer" that they, or he, should have some clear idea of what he proposes to do. First, though, let him banish from his vocabulary the indefinite term " engineer," and then select some specialty from the many occupations open to him. The field is almost unlimited. He can become a bridge-builder, but he must make up his mind whether he will build them of metal, of wood, or of stone. He might make water-closets and call himself a " sanitary engineer," but the assumption of the title will not change the nature of his occupation. It should be impressed on his mind though that to be successful he must enter and confine himself to some narrow field, and that the principles which would command success if he were a maker of mouse-traps or a vendor of cheese will have a great deal to do with his success even if he gives himself the fine title of " engineer."

To young men who want to be engineers, and to their parents, it should be said that there is usually nothing very grand about the occupation. Success in it is governed by very much the same considerations as control other kinds of business. The thing to be aimed at is to learn how to do some one thing as well or better than any one else can do it. If a person goes into the manufacture of steam-engines, he must make as good or better engines than other makers are producing, or he will lose his trade. If he seeks employment he will soon find that what people are willing to pay for is special, not general knowledge—that is, individuals, firms, and companies hire employés for their ability to do some special thing well. A railroad company will hire an engineer because he knows how to locate a railroad or maintain it as well as any one else could, but is probably indifferent to his other qualifications. A draftsman is employed because he knows how to draw and design some special kind of structure. A foreman of works is hired because he understands the practical work of the shop, and has the needed energy and skill to get out work.

The question as to the preparatory training which will best qualify a person for an engineering occupation is one which has been much discussed of late. It may be said, without hesitation, that very little scientific education is absolutely essential to make a successful engineer. This is proved by the fact that a very large proportion of those who have succeeded in this country and in Europe have had only a very limited scientific education. But this is like saying that a good workman can do a good job with poor tools. The need of a higher degree of technical training is each year becoming more essential. It is undoubtedly true that a young man who begins his career with a good education has now a very great advantage over one who starts without such an equipment. But it should be remembered that students cannot be taught how to practise a profession in a school. What seems to be an error in the teaching of technical schools of the present day is a disposition to try to teach a trade or profession. As Sir William Armstrong, in an article reprinted on another page, very truly says, " A man's success in life depends incomparably more upon his capacities for useful action than upon his acquirements in knowledge, and the education of the young should, therefore, be directed to the development of faculties and valuable qualities rather than to the acquisition of knowledge, which may be deferred to more mature age ;" or as an experienced educator has expressed it, " Mental growth consists largely in the power to abstract the mind from the things of sense, and to handle the thought when not clothed in matter." Education should bear the same relation to the mind that gymnastics do to the body. In a gymnasium the exercises are not selected for any other use excepting that of exercising the body. So in a school, studies should be chosen with a view chiefly to the exercise and training of the mind. It is not of any very great importance how the mind has been trained, but it is important to persons who now engage in any branch of engineering that they should be able to comprehend, analyze, and investigate the subjects which every year become more abstruse and require a higher degree of mental culture to understand.

NEW PUBLICATIONS.

AN INDEX TO ENGINEERING PERIODICALS, 1883 TO 1887, INCLUSIVE. COMPRISING ENGINEERING; RAILROADS; SCIENCE; MANUFACTURES AND TRADE: BY FRANCIS E. GALLOUPE, M.E. Boston; published by the Author (price, $2).

Mr. Galloupe presents in this volume an index which is evidently the result of much patient labor, and which must

be an exceedingly useful labor-saving book to all engineers who use it. So much of the best engineering literature is now published in the various periodicals that complete books on any technical subject are growing more difficult to find ; and the engineer who would keep up with the progress made in his branch of the profession must be a student of the magazines and papers. But some of these are not well indexed, and even with those which do provide their readers with this necessity, it would be impossible always to remember in which one an article was published, so that a long search through a number of indices would be required to find it.

Mr. Galloupe has undertaken to help the busy reader by supplying a general index covering 19 of the leading engineering periodicals, American and English. His index is carefully arranged by subjects, and contains over 10,000 references. With this the searcher cannot only find any special article which he wants, but can also readily get at what has been published on any special subject.

The utility of this volume will be apparent to every one, and it is to be hoped that it will have the extended sale which it deserves. It may be safely said that no one who has once had occasion to use it will be willing to give it up.

We understand that Mr. Galloupe hopes hereafter to extend his work, making it cover additional years, and take in also the *Proceedings* of the various engineering societies. This will be a good work, and one deserving all possible encouragement.

The book is published in very neat form. The references are plain, and the arrangement by subjects a very good one.

REPORT OF THE PROCEEDINGS OF THE TWENTY-FIRST ANNUAL CONVENTION OF THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

This report has been issued very promptly this year, and has made its appearance within two months after the meeting was held. It is of about the usual size and character, and shows the Association to be in a prosperous condition. The membership has increased from 277 last year to 322 this. The committee reports are perhaps somewhat less interesting than usual, but as the Association has been receiving, and the members writing, reports on locomotives for twenty-one years, it is perhaps not remarkable that it becomes difficult to say anything new or interesting on these subjects. Still, if the members depended less on the opinions of their colleagues in making their reports, and more upon their own observations and study, perhaps what they write would be newer, more interesting and valuable than it now is. If, for example, any of the members who have the care of a considerable number of locomotives would keep a careful record of all their breakages and failures on his road during one or more years, and should give an accurate and specific report and description of each, with drawings showing the character of the breakages, when such drawings are needed, it would form a valuable contribution to our knowledge of locomotive performance. Careful and accurate notes of the effects of corrosion on all the locomotive boilers of a line on which the water is bad would also be useful. A locomotive superintendent or master mechanic has under his eyes daily a series of object lessons from which much more interesting reports could be made than it is at all likely he can evolve by any process of scientific deduction.

During one of the meetings there was some discussion of the benefit to the Association of its associate members, in which there was a flavor of animadversion for which there may be good reason. But it should be observed that as such members occupy the relation of guests to the Association, they are therefore not in a position to take a very active part in the proceedings ; and to assume that "personal gain" is the only motive which leads persons to become associate members is putting a low estimate on those motives. The fact is, it is a great honor for the Association, by an almost unanimous vote—and it must be nearly unanimous to elect an associate member now—to say to a person—as it does say when an associate member is elected—"We think that you have such a knowledge of science or such practical experience in matters pertaining to the construction of rolling stock as would be of *especial* value to us or to railroad companies," and therefore you have been elected an associate member. Such an election should be regarded by both parties as an honor, and not as a license for axe-grinding, for which the Association is expected to supply the motive power.

SPECIAL TOOLS FOR RAILWAY REPAIR SHOPS. Philadelphia ; Pedrick & Ayer, 1025 Hamilton Street.

This firm have just issued a new edition of their descriptive catalogue, which is very neatly printed with tinted margins and very good engravings of the tools and machines they make. These are milling machines, with chucks, index heads, and other attachments, cylinder boring and facing machines, universal tool-grinding machines, apparatus for heating, setting, and removing tires, and its application to heating and straightening boiler plates, valve-seat rotary planing machines, portable valve chucks, portable cylinder boring machines, crank-pin machines, Greenwood's planer chucks, steam chest seat milling machines, wrist-pin machines, flue-cleaning machines, planer tools, jointer for facing brasses, link-grinding machines, radius link planers, portable drilling machines, cylinder planing chucks, mandrels for turning eccentrics, shrinkage gauges, boiler tube cutters, car-wheel circumference measures, portable key-seating machines, portable bench vises, portable hand drills, extension jacks, the "Gyp" engines, etc.

It is a very excellent example of this kind of literature with full and lucid descriptions of the machines which are illustrated, in which such publications are often lacking.

ABOUT BOOKS AND PERIODICALS.

AN article of especial interest appears in the August number of NEW YORK RAILROAD MEN, entitled "Why Railroads are Made," by Walter Katte. The Author discovered that a much wider field was opened for him to cover than he had any idea of at the outset, but his experience on this subject enables him to do it justice.

In SCRIBNER'S MAGAZINE for August, the fourth article on the Railway Series is contributed by General Horace Porter, on Railway Passenger Travel. General Porter has the faculty of bringing out the most interesting and striking features of the subject. He also touches upon the questions of car-couplers, steam-heating switches, checks, immigrant transportation, and the ratio of accidents.

A very interesting chapter in the early history of ironclads appears in the August CENTURY, where the story of

the Confederate cruiser *Albemarle* is told by the officer who designed and superintended her construction, and by several of those who tested her fighting powers. The *Albemarle* was necessarily an experiment, and was built under many difficulties, but was nevertheless a fighting ship with considerable power of resistance. The attempt of the wooden ship *Sassacus* to sink or disable the *Albemarle* by ramming was one of the boldest exploits in our naval history. The CENTURY gives a history of the ship from her first building to her destruction by a torpedo. Perhaps the thing which strikes one most in reading this article is the very small advance which has really been made in the 24 years since the *Albemarle* ran her brief course. Our modern ships have been improved in detail, but are hardly any better fighting machines, after all, and there has never been a better instance of the use of the torpedo than when Lieutenant Cushing fixed one under the *Albemarle* in the Roanoke River.

THE CARS IN PROPHECY AND HISTORY is an extraordinary book, in which the Author, Rev. D. T. Taylor, present proofs (?) of the nearing end of the age. The Author says, "A railway train moving but a mile a minute dashes over the ground 88 ft. every second. This is literally to dart or shoot. Ancient travel was at a snail's pace compared with the speed of the man whose hand controls the engine. This is the chariot of fire! Settle in your hearts then, reader, that here is a Divine prediction made 2,500 years ago in Asiatic lands of the coming of an extraordinary age of travel, travel in great haste; and this infers new methods, new facilities, and new powers at the command of man. Are such methods in use? Then the prediction is accomplished, the consummation near." Again, "The discovery of the practical use of steam and electricity was reserved for these closing days of this world's history, when the king's business would require haste." The book reads like the work of one who is sincere, but so chimerical as to be hovering on the border between sanity and insanity.

BOOKS RECEIVED.

ANNUAL ACCOUNTS AND STATEMENTS OF THE COMMISSIONERS OF SEWERAGE AND WATER SUPPLY FOR THE CITY OF ST. JOHN (EAST SIDE) AND TOWN OF PORTLAND: GILBERT MURDOCH, C.E., ENGINEER AND SUPERINTENDENT. St. John, N.B.; published for the City.

PROCEEDINGS OF THE INDIANA SOCIETY OF CIVIL ENGINEERS AND SURVEYORS AT THE EIGHTH ANNUAL MEETING, HELD IN INDIANAPOLIS, JANUARY 17, 18 AND 19, 1888. Indianapolis, Ind.; issued by the Society.

AMERICAN INSTITUTE OF ARCHITECTS: PROCEEDINGS OF THE TWENTY-FIRST ANNUAL CONVENTION, HELD IN CHICAGO, OCTOBER 19, 20 AND 21, 1887. E. H. KENDALL AND A. J. BLOOR, EDITORS. New York; published by the Institute.

HEATING PASSENGER CARS BY STEAM FROM THE LOCOMOTIVE: REPORT OF PROFESSOR GAETANO LANZA. Boston; published by the Massachusetts Institute of Technology.

DRY STEAM THE FOUNDATION OF ECONOMY. New York; published by the Stratton Separator Company.

THE PROPOSED CHANGE OF PLAN IN THE EXECUTION OF RIVER AND HARBOR IMPROVEMENTS: THE ORGANIZATION OF A CIVIL BUREAU OF HARBORS AND WATERWAYS. This is a reprint of the arguments presented before the Congressional committees on the Cullom-Breckenridge bill by a committee of the Engineers' Club of St. Louis.

POCKET HAND-BOOK OF COPPER AND IRON WIRE IN ELECTRIC TRANSMISSION AND THE WORLD'S FACTS OF ELECTRIC SERVICE. Worcester, Mass.; issued by the Washburn & Moen Manufacturing Company. This little book, in addition to the catalogue of sizes and electrical resistances of different kinds of wire, contains in a condensed form a number of useful facts in relation to electricity, including a brief dictionary of electrical terms and an index of current electrical literature.

Running Long Tangents.

To the Editor of the Railroad and Engineering Journal:

CAN you say if bearings in a railroad survey are all taken from some one particular meridian or not? If not, suppose you were running a long east-and-west (or nearly so) tangent, say 100 miles, at its end it would have a different bearing, but still be a straight line; and how often would true meridians be taken and reading of azimuth, as you might say, change? This would be a very interesting point, and among the list of railroad engineering writers not the first one has ever said what is the customary practice on this point.

Larimore, Dak. L. S. CARRUTH.

[In a railroad line 100, 200, or more, miles long the bearings are not taken from any one particular meridian, but are taken by each engineer in reference to the true meridian upon his part of the work.

In running a tangent, say 50 or 100 miles long, the bearings would have very little to do with it, with the exception of one running due north and south.

As many prominent points as possible would be established on the proposed tangent by means of triangulation or trial, or, as is often the case in a country where a long tangent is possible, some prominent, permanent point, such as a mountain-top, church steeple, etc., is taken as a fore-sight.

However the points are obtained, a long tangent should always be run by fore-sights only, using the back-sights as a check on the adjustment of the transit.

The bearing could be taken as often as desired, but it would not be used in the running of the tangent.

In latitude 40° any tangent starting with a due east-and-west bearing will have the bearing changed about $0\frac{3}{4}'$ in every mile, and as the compass needle reads only to about 15 minutes, a difference would be noticeable only every 15 or 20 miles.

But on all railroad work the great reliance for accuracy is placed in the precision of the transit and angular measurement, not on the bearings of the lines.—C. D. J.]

Gas as a Supplement to Steam in Heating Cars.

To the Editor of The Railroad and Engineering Journal:

HAS the car-heating question become *res adjudicata?* So far as the use of steam from the engine after the cars are in motion is concerned, it undoubtedly is so; but how much further? In other words, are stationary steam boil-

ers and coal furnaces—the means now relied upon for heating cars when steam from the engine is not available—the best that can be used for that purpose ?

Judging from appearances, our railroad companies think they are, and therefore, in the absence of proof to the contrary, will naturally act upon that opinion, as the time for fitting up their cars for winter use is now so limited.

The question, therefore, Can such "proof to the contrary" be given ? becomes of immediate moment, as we think the following facts and inferences will show, stated here, so far as they relate to steam plants and coal stoves, not because I think they are in any way new, but that they may be considered in close contrast with what is stated afterward.

1. Relating to steam plants. As they answer for no other purpose than to heat the cars for the short time before the engine comes, and even for that inconveniently when several trains are to be heated at the same time, as occurs at terminal points on all trunk lines ; and when used as a system must be provided at all stations where trains are made up, and kept always ready for use, however limited it may be ; it is evident that nothing but necessity can justify the great cost necessary for their use.

2. Relating to heaters and coal stoves. As it is not pretended they can be used for preliminary heating, as for that use the fuel must be removed from them through their doors after short use, and in a glowing state, before the car leaves the station where the train is made up, they must be kept in the car, if kept at all, for no other use than as a substitute for the engine when it breaks down, and so again nothing but necessity can excuse their use.

3. Assuming, as I think I have proved, that nothing but necessity can justify the use of steam plants and coal heaters as supplements to steam from the engine in heating cars, we come to the question, Does that necessity exist ? or rather to the question—If gas can be practically used for the purpose above stated, is it not a better means for it than steam plants and coal stoves ? as if it is not there is no other, and if it is, nothing touching the interests of railroad companies is more important for them to know.

We therefore ask their serious attention to the following facts, beginning with an explanation of why gas has not been practically used for heating cars hitherto, before considering why it should be so used hereafter, as, until we remove the prejudice now existing against it for such use, it is useless to go on.

If we examine the apparatus in general use for burning gaseous fuel, we will find that it consists of an open case provided with perforated pipes for burning the gas, but without means for confining the air passing through it to the gas jets, or in any way regulating its flow to what is required for combustion ; and that the system upon which the gas is burned in it is what is known as the Bunsen system—*i.e.*, mixing air with the gas previous to burning it in the proportion of 2 to 3 parts air to 1 of gas.

It follows that, as the fuel used in a Bunsen stove is only one-third gas at its ignition point, the heat there generated is not sufficient to maintain continued combustion thereafter, and therefore its products (chiefly carbonic oxide), instead of being burned up, must largely pass off as waste, proved also by the fact that the makers of Bunsen stoves always advise they should never be used without a flue to the chimney to prevent said waste from being breathed—C O being a very poisonous gas. Nor is that all, as, even assuming that the objections to Bunsen stoves are compensated for by their convenience when they are used for small purposes, where the direct impact of flame does the work, and therefore the draft can be kept down, there can be no question that when gas must be burned in quantity and under draught, and heat alone must be relied on (as must be the case in heating cars), its use in the apparatus now in general use for burning gaseous fuel must be attended with still greater waste, as when so used at least one-half of the heat generated is lost from the cold air dilution to which it is exposed in doing its work, as more of the air entering the apparatus passes around and away from its flame than in contact with it.

And it is for these reasons, much more than from defects of constitution so far as manufactured gas is concerned, and, so far as natural gas is concerned, from its being burned from open pipes and therefore at excessive waste,* that gas as a fuel has been so underestimated, speaking not only from our own knowledge, but from the opinions of some of the ablest gas engineers in this country.

Having now cleared the way, I trust, to a fair treatment of the question, Whether gas can be practically used for heating cars ? we come to what is required to make it so—to wit, How it must be burned ; how it must be used ; and what it will cost.

1. How it must be burned.

Having shown how it must *not* be burned, the answer to this question is easy : by using the gas in a pure state (instead of diluted with air 2 to 3 times, as it is in a Bunsen stove) on its issue from the burner, to ensure the highest heat possible at that time ; and so construct the furnace that the air used in it for combustion must strike into the gas instead of merely slide over it at its point of ignition, and that no air whatever can pass beyond that point except in contact with flame ; so that not only when combustion commences, but thereafter, the furnace will operate with an automatic draft—viz., more or less air as more or less gas is burned, and therefore nothing but undiluted heat can enter its flues. Now contrast this construction and operation with those of the apparatus now in general use for burning gaseous fuel, and you will not be surprised when I state from my own experience that when large amounts of gas are burned the quantity required in the former case, when compared with what is required in the latter, will be as 1 to 3.

2. How it must be used.

Doubtless there may be other answers to this question, but however that may be, the following should be a satisfactory one, as it meets all the conditions required to make it so—to wit : in a furnace which will burn the gas with an automatic draft, so that whether much or little of it is used there will be no material waste of fuel or heat ; which can be used without inconvenient or expensive alteration of the cars, and supplied with gas through pipes placed under them and connected between them, as steam pipes now are, so that the gas used can come direct from street mains (to avoid the cost and care of storage tanks and their complicated connections), and when so used all the furnaces in a train can be supplied from one connection with said mains, turned on when the heating commenced and off when the engine came ; which is so constructed that it can be changed from a gas to a coal burner or back again

* There must be much improvement in burning natural gas at present, but when I was at Pittsburgh I estimated the amount wasted, as it was burned under boilers then, to be 90 per cent. of the amount used ; and yet we find the results from its use quoted, even in scientific journals, as proving gas to be a weak fuel.

in a few minutes, and without other trouble than removing a plate left movable for that purpose, to provide for cases where trains are made up at stations where there is no gas, and for cases where, from the disabling of the engine away from terminal points, the cars would be left without heat if dependent for it upon the engine alone; and finally, which will use the fuel in it, whether gas or coal, indirectly—to wit, through the medium of steam, so that, whether the car is heated by it or from the engine, only one direct heating agent will be used—to wit, steam.

As objections have been made to generating steam on the car, which would require water to be carried in the boiler used, I add that from the short time such steam would be required, viz., about half an hour a day, the small quantity of water used could easily be put into the boiler when the train was made up, and what remained when the engine came could as easily be run out. It should also be added that, while we think the use of steam alone is preferable for the reasons we have stated, the furnace can as well be adapted to heating the cars with warm air, or radiation from its surface and flues, when so preferred; and when it is so used even has some advantages, to wit, less weight and cheaper construction.

3. What it will cost.

(1st) For the apparatus required, not materially over $100 per car when it is constructed as we have described, as but one apparatus is used, and no other alteration of the car required (except for the pipes under it, when it is desired to heat a train from one connection with the gas mains under the track) than to substitute it for the stove at present used.

(2d) For the gas used. There is no question that the time is near when gas will be generally used as fuel, in which case its consumption will be so greatly increased that the price at which it can be sold will be at most, even for carbureted gas, $1 per 1,000 ft., and in large cities much less.

But, waiving that inference, when gas, as now made—from 18 to 25 candle-power—is burned as we have described, the time used by it to heat a car so far as required before the engine comes cannot exceed 25 to 30 minutes, as, when the apparatus used is properly constructed, the steam generated in it should form quite freely in 10 to 12 minutes.

If, then, the gas is burned even at the rate of 60 ft. to 80 ft. per hour, the amount required to heat the car for one trip, however extended it may be, will not average over 35 ft., costing, at even $1.50 per 1,000 ft., 5¼ cents.

But suppose its cost was twice that, would not gas even then be preferable to steam plants and coal stoves, without taking into the account the inconvenience of keeping the latter in the car, if kept at all, as useless weight, except only for the few occasions when the engine breaks down?

It will be observed that we have said nothing in this paper relating to the use of gas for lighting purposes, as to treat that subject properly would require more extended notice than the length of this paper will permit, especially as we would have to take electricity into the discussion.

But we will hazard a single reflection germane to the matter. Taking into the account the cost and complication attending the use of electricity for lighting cars, is there any common-sense in using it for that purpose in preference to gas, when the use of the latter is being daily improved, and its cost will soon be $1 per 1,000 ft. in all large cities, and much less when it is generally used as a fuel, as it soon will be? HENRY Q. HAWLEY.

The Sun Motor.

(Captain John Ericsson, in *Nature*.)

INDIA, South America, and other countries interested in the employment of sun power for mechanical purposes have watched with great attention the result of recent experiments in France, conducted by M. Tellier, whose plan of actuating motive engines by the direct application of solar heat has been supposed to be more advantageous than the plan adopted by the writer of increasing the intensity of the solar rays by a series of reflecting mirrors. The published statements that "the heat-absorbing surface" of the French apparatus presents an area of 215 square feet to the action of the sun's rays, and that "the work done has been only 43,360 foot-pounds per hour," furnish data proving that Tellier's invention possesses no practical value.

The results of protracted experiments with my sun motors, provided with reflecting mirrors as stated, have established the fact that a surface of 100 square feet presented at right angles to the sun, at noon, in the latitude of New York, during summer, develops a mechanical energy reaching 1,850,000 foot-pounds per hour. The advocates of the French system of dispensing with the "cumbrous mirrors" will do well to compare the said amount with the insignificant mechanical energy represented by 43,460 foot-pounds per hour developed by 215 square feet of surface exposed to the sun by Tellier during his experiments in Paris referred to.

The following brief description will give a clear idea of the nature and arrangement of the reflecting mirrors adopted by the writer for increasing the intensity of the solar heat which imparts expansive force to the medium propelling the working piston of the motive engine. Fig. 1 represents a perspective view of a cylindrical heater, and a frame supporting a series of reflecting mirrors composed of narrow strips of window-glass coated with silver on the under side. The frame consists of a light structure of wrought iron or steel provided with transverse ribs, as shown by the illustration, each rib being accurately bent to a parabolic curvature, whose focus coincides with the axis of the cylindrical heater. It need hardly be stated that the mirrors supported by the said transverse ribs continue from side to side of the frame, which accordingly resembles a parabolic trough whose bottom is composed of mirrors. It will be readily understood that this trough, with its bent ribs and flat mirrors, forms a perfect parabolic reflector, to which a cylindrical heater, as stated, may be attached for generating steam or expanding the gases intended to actuate the piston of the motive engine. Regarding the mechanism for turning the reflector toward the sun, engineers are aware that various combinations, based on the principle of the "universal joint," may be employed.

Concerning previous attempts made in France to utilize solar energy for mechanical purposes, it is well known that practical engineers, having critically examined Mouchot's solar engine, which M. Tellier proposes to supersede, find that it is incapable of developing sufficient power for any domestic purpose. Again, the investigations carried out by order of the French Government to ascertain the merits of Mouchot's invention show that, irrespective of the great expense of silver-lined curved metallic reflectors for increasing the insufficient energy of direct solar radiation, these reflectors cannot be made on a sufficient scale for motors having adequate power to meet the demands of commerce; nor is it possible to overcome the difficulty of rapid wear of the delicate silver lining of the metallic reflectors consequent on atmospheric influence, which, after a few hours of exposure, renders their surfaces tarnished and ineffective unless continually polished. A glance at the accompanying illustration (fig. 1) shows that the reflector constructed for my sun motor differs altogether from that originated by Mouchot, which Tellier's apparatus, tested at Paris, was intended to displace.

1. The mirrors which reflect the solar rays are devoid of curvature, being flat narrow strips of ordinary window-glass cut to uniform width and length, perfectly straight.

2. The under sides of said strips are coated with silver by a process which prevents the action of the sun's rays from destroying the silver coating, as in ordinary looking-glasses.

3. The mirrors supported by the bent metallic ribs extending from side to side of the parabolic trough are held down by the heads of small screws tapped into the ribs. Thin slats of wood may be introduced between the mirrors

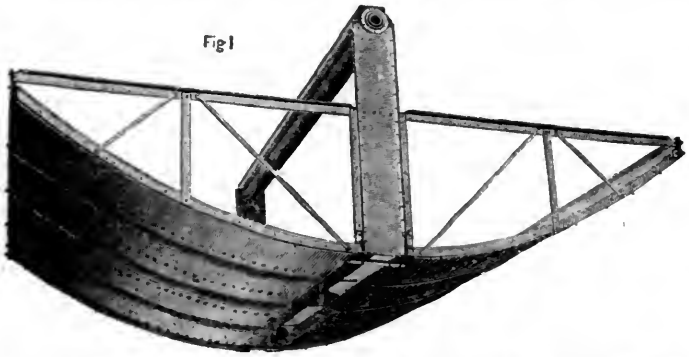


Fig 1

and the ribs—an expedient of some importance in localities where the reflector is exposed to high winds.

4. It needs no explanation that the *reflecting surface* of the mirrors cannot become tarnished by atmospheric influence, since the bright side of the silver coating is permanently protected by the glass; hence it will be only necessary to remove *dust* from the mirrors, an operation readily

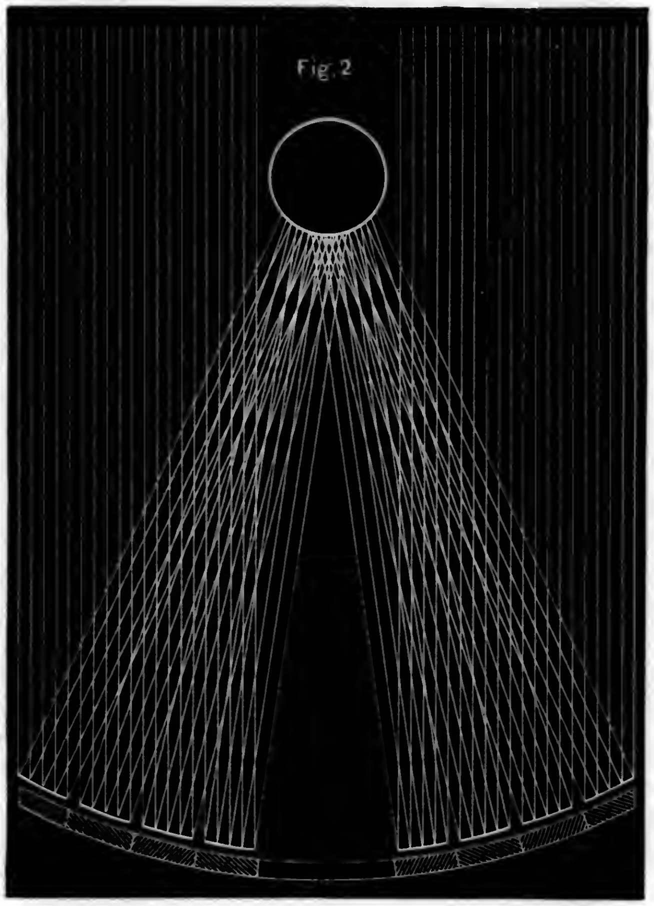


Fig. 2

performed by feather brushes secured to light handles of suitable length.

5. The frame of the reflector, being composed of rolled bars of iron or steel, requires no finish, excepting the top of the transverse ribs, which must correspond accurately with a given parabolic curvature. It should be observed that the needed accuracy is readily attained by a cutting tool guided by a bar of proper form.

6. Regarding cost of construction, it will suffice to state that manufacturers of glass, both in the United States and Germany, supply the mirrors, cut to exact size and silvered, at a rate of 60 cents per square foot, the weight being 106 pounds per 100 square feet. Consequently the cost of the reflector and heater for the sun motor will not much exceed that of a steam boiler and appurtenances, including chimney. The cost of the engine, apart from the reflector, will not be greater than that of an ordinary steam-engine.

7. With reference to durability, it will be evident that the light metallic frame with its mirrors, and a heater acted upon only by reflected solar heat, will last much longer than steam boilers subjected to the action of fire, soot, and corrosion.

Let us now briefly consider the distinguishing feature of the sun motor—namely, the increase of the intensity of the sun's radiant energy by *parallel* rays and *flat* reflecting surfaces permanently protected against atmospheric influence. It has been supposed that the lens and the curved reflecting surface, by converging the sun's rays, could alone increase the intensity of radiant heat. But Newton's demonstration, showing that the temperature produced by solar radiation is "as the density of the rays," taught me to adopt, in place of curved surfaces and converging rays, flat surfaces and parallel rays, as shown by fig. 2, which represents a transverse section of part of the reflector. The direct vertical solar rays, it will be seen, act on the mirrors; while the reflected rays, divided into diagonal clusters of parallel rays, act on the heater, the surface of which will thus be exposed to a dense mass of reflected rays, and consequently raised to a temperature exceeding 600° F. at noon during ordinary sunshine.

The cost, durability, and mechanical energy of the sun motor being thus disposed of, it remains to be shown whether the developed energy is continuous, or whether the power of the engine changes with the increase and diminution of zenith distance and consequent variation of atmospheric absorption. Evidently an accurate knowledge of the diathermancy of the terrestrial atmosphere is indispensable to determine whether the variation of the radiant energy is so great that the development of constant power becomes impracticable. Of course, manufacture and commerce demand a motor developing *full power* during a modern working day of *eight* hours. Observations relating to atmospheric diathermancy, continued during a series of years, enable me to assert that the augmentation of solar intensity during the middle of the day is so moderate that, by adopting the simple expedient of wasting a certain amount of the superabundant heat generated while the sun is near the meridian (as the steam engineer relieves the excess of pressure by opening the safety-valve), a uniform working power will be developed during the stipulated eight hours. The opening of the safety-valve, however, means waste of coal raised from a great depth at great cost, and possibly transported a long distance, while the radiant heat wasted automatically by the sun motor is produced by fuel obtained from an inexhaustible storehouse free of cost and transportation.

It will be proper to mention that the successful trial of the sun motor heretofore described and illustrated in *Nature* attracted the special attention of landowners on the Pacific Coast then in search of power for actuating the machinery needed for irrigating their sun-burnt lands. But the mechanical detail connected with the concentration at a single point of the power developed by a series of reflectors was not perfected at the time; nor was the investigation relating to atmospheric diathermancy sufficiently advanced to determine with precision the retardation of the radiant heat caused by increased zenith distance. Consequently no contracts for building sun motors could then be entered into, a circumstance which greatly discouraged the enterprising Californian agriculturists prepared to carry out forthwith an extensive system of irrigation. In the mean time, a simple method of concentrating the power of many reflectors at a given point has been perfected, while the retardation of solar energy caused by increased zenith distance has been accurately determined, and found to be so inconsiderable that it does not interfere with the development of constant solar power during the eight hours called for.

The new motor being thus perfected, and first-class manufacturing establishments ready to manufacture such machines, owners of the sun-burnt lands on the Pacific Coast may now with propriety reconsider their grand scheme of irrigation by means of sun power.

THE PRINCIPLES OF RAILROAD LOCATION.

By Professor C. D. Jameson.

(*Continued from page* 349.)

CHAPTER XXIX.

EFFECT OF CHANGES IN THE RATE OF THE RULING GRADE.

As we have seen, the effect upon the cost of operating of changes in the rate of grades that are not the ruling grades is very little. and comparatively little money can be spent economically to make these reductions; in the case of any reductions of the ruling grade, however, the case is entirely different. The ruling grade, as has been before explained, is that grade which from any cause limits the weight of the trains that can be hauled over that section of the road. This limiting effect may arise from the rate of grade, the length of grade, or the relative position of the grade.

As has been shown in the preceding chapter, the steepest grade on a section may be so situated in reference to the preceding grades that its rate is very much reduced practically.

The train being able to take advantage of acquired surplus of speed to surmount it, therefore the Ruling Grade on a section of railroad is the steepest Virtual Grade.

The load that can be hauled by a locomotive on a level is in proportion to the weight which comes on the driving wheels, as the greater the weight on the drivers the greater will be the friction between the drivers and the rails, and the greater the resistance to the slipping of the drivers on the rails. By "slipping of the drivers" is meant the turning of the drivers without a corresponding movement of the locomotive. This is due to the fact that the amount of power applied to the drivers is in excess of the friction between the rails and the drivers, and the amount of power that is applied to the drivers depends upon the weight of train that is behind the engine, or the resistance to motion that must be overcome. Therefore, when this resistance to motion is greater than the friction between the surface of the rails and the drivers, the train cannot be moved. Either the drivers do not turn at all or else they turn without going ahead. As was said before, the amount of hauling or tractive power of the locomotive depends upon the weight upon the drivers. This is only true as to the relative tractive power of any number of locomotives under exactly the same circumstances.

As regards the absolute traction of any locomotive having a given weight on the drivers, this varies continually with the varying circumstances—that is, such circumstances as affect the coefficient of friction between the rails and the driving wheels. The condition of the surface of the rail is the most important factor in this respect, whether the rail is wet or dry, or whether covered with frost, ice or snow. . But taking a dry rail in a fairly good condition, and everything in relatively good working order on the locomotive, the tractive power may be taken as one-fourth the weight on the drivers—that is, suppose the weight on the drivers is 40 tons, the tractive power of the locomotive would be 10 tons, or, in other words, it could exert a pull of 10 tons on any train behind it.

In considering the tractive power of a locomotive we have taken into account only the weight on the drivers, as that is the only element in the construction of the locomotive that the civil engineer need consider, from the fact that the engineer is not supposed to design the details of the locomotive, but simply regards it as a machine so proportioned as to be able to exert a power greater than the frictional resistance between the rails and drivers, and consequently having its tractive power limited by the amount of this friction, and indirectly by the weight on the drivers and the condition of the rails.

The limiting factors to the power of a locomotive regarded simply as an ordinary steam-engine are the dimensions and arrangements of the fire-box, or the capacity for generating heat, and the boiler capacity, which, in connection with the heat-generating capacity, limits the amount and pressure of the steam. The cylinders act simply as a means of conveying the force or power contained in the steam to the driving wheels, or the point where it is changed into work.

From what has been said it will be seen that one point to be studied in designing a locomotive is to throw as much of the total weight of the locomotive upon the drivers as is practicable. This has been accomplished in various ways. The weight of the locomotive rests upon the driving wheels and trucks. The driving wheels are those that are connected with the piston-rod by means of the connecting rod; these are called the main drivers, and those wheels which are connected with the main drivers by means of coupling rods are called trailing wheels. The remaining wheels under the locomotive are called truck wheels and serve simply to support the weight without in any way increasing the tractive power. By increasing the number of drivers there is more weight thrown on them, and the tractive power is increased. In the case of locomotives built for special service, where great tractive power is needed and speed of no consequence, such as engines to be used only in yards for switching, making up trains, etc., the whole weight is sometimes thrown upon two or three pairs of drivers, with no trucks at all; and, in order to make this weight as much as possible, and still not carry any useless load, the tank which carries the water, instead of being carried upon a separate car or tender, as is usually the case, is built around the boiler, and brings all its extra weight to bear on the drivers, thereby increasing greatly the tractive power of the locomotive. Another advantage of these yard or tank engines is the ease and facility with which they run round the sharp curves which of necessity occur in railroad yards. This is due to the fact that the whole wheel base is simply the distance between the drivers, and is consequently much less than if there were more drivers or trucks, as in ordinary locomotives.

It must be remembered, however, that these remarks as to weight on drivers must be accepted with certain practical limitations, imposed by the design and construction of the locomotives in ordinary use, and also by the necessity of considering the weight per wheel which the track will bear.

As has been stated, the tractive power of the locomotive may be taken at one-quarter of the weight on the drivers, with wheels and rails in fairly good condition, and the resistance to movement of the train behind the locomotive at 9 lbs. per ton on a straight and level track.

The weight of the train behind the tender is made up of two items: 1. Dead or non-paying load—that is, the weight of cars, etc., in which the freight or passengers are carried.

2. Live or paying load—that is, the freight or passengers, for the carrying of which the railroad company receives certain sums of money, from which the operating expenses, all charges, interest, etc., must be paid, and the surplus from which (if any) forms the profit on the money invested in the road, and (sometimes) goes to the stockholders in the form of dividends.

In considering the question of paying train-load, we will here take freight trains only, for the reason that more than three-quarters of all the business done by the railroads of the United States is in freight, and in every way the freight traffic is the ruling and important element in railroad business and the source from which the greater part of the revenue is drawn, except in the case of a few lines exceptionally placed—such as the lines between New York and Philadelphia, the New York, New Haven & Hartford, and a few others carrying suburban traffic near the larger cities.

The carrying capacity of the freight car has been practically doubled during the last few years, and a still further increase is probable. This increase in load has been very much greater proportionally than the increase in weight, until now we have freight cars which, when loaded up to their maximum limit, can carry nearly five times their own weight. In some few cases a load of five times the weight of the empty car has been actually reached, as with cars carrying coal, iron ore, stone, etc.

Taking the railroads of the country as a whole, however, this is not the case, and the proportion of paying to non-paying load is much less. This results from the fact that it is absolutely impossible that every car in a freight train should be fully loaded. This is not so much the case with through freight as with way freight, for the reason that for through freight, most of the material being billed to the same point and only forwarded at regular intervals, the cars can be more economically loaded. But in the case of way freight we reach the minimum of economy in the loading of the trains, and the dead load often equals and frequently exceeds the live load. As an average for all the railroads in the United States, we can take the total weight of car and load as 25 tons, of which 10 tons is the dead weight of the car, and 15 tons the average paying load per car. This same proportion will hold good of a train, and we may consider the average train behind the locomotive as made up of 40 per cent. dead load and 60 per cent. live load. This calculation, however, involves the assumption that the traffic in both directions is nearly equal; the actual figure for live load is, in practice, probably much less.

Any change in the ruling grade causes a corresponding change in the load that can be hauled by the locomotive, and the greater part of this change comes upon the paying load. Of course the actual amount of money that can be economically spent to reduce the rate per cent. of the ruling grade depends to a great extent upon what the rate of the ruling grade is, or, rather, what proportion the change will bear to the ruling grade—that is, much more can be spent to reduce a ruling grade from 0.5 per cent. to zero than from 2 per cent. to .5 per cent. For in the first case we reduce the resistance of the train in pounds per ton from 20 to 10, or one-half, thus doubling the load that can be handled, while in the second case we only reduce it from 50 to 40 lbs. per ton, and thus only increase the possible load one-quarter.

It must be remembered also that when we have arrived at any definite amount that can be expended to reduce the ruling grade, that it is to reduce the rate *per cent.* of the ruling grade, and not any definite number of vertical feet rise, as in the case of minor grades; and, further, that the reduction must be of the whole ruling grade contained in any one section and not simply of one or more parts of it. When the reduction in ruling grade is only made in some portion of it, the ruling grade proper remains the same as before, and the only gain to the railroad is that due to a reduction in any grade not the ruling grade.

CHAPTER XXX.

RELOCATIONS AND IMPROVEMENTS.

In locating a railroad, the possibility should always be borne in mind that, however small the amount of traffic may be that will be done by the road during the first few years, this traffic may grow to enormous proportions in the near future, either by the development of the resources of the section of country through which it runs, or by its becoming in the course of time a link in some long trunk line.

In either case it will be justifiable for the road to ultimately expend a vast amount of money in reducing its grades, curves, and, where this increased traffic is all hauled over its own line, in reducing its length. When the road considered, however, simply forms a part of a trunk line, it may be a positive loss to reduce its length.

This is due to the fact that in any through line made up of a number of independent companies, the amount charged for transportation is not based upon the exact distance hauled, and does not vary as that distance. It is wholly governed by competition and outside circumstances that are to only a very slight extent controlled by the actual distance. But although the rates charged are not proportional to the distance hauled, still, when it comes to dividing this rate among the different roads that go to make up the through line, the division is usually in exact proportion to the number of miles of road each company owns, so that the greater the proportion of the whole that is owned by one company, the greater will be that company's receipts.

Therefore, if a company forming part of a through line spends money to reduce the length of its road, it is simply doing an act of charity.

It loses the interest on the expenditure and reduces its share of the gross receipts, while the other companies that make up the line are the gainers.

For example, suppose a through line to be composed of three separate railroads, of the following lengths: *A*, 50 miles; *B*, 30 miles, and *C*, 20 miles, making a total of 100 miles.

Suppose the rate per ton for transportation to be 90 cents, then a division of this rate proportionately to the length of each road would give: *A*, 45 cents; *B*, 27 cents, and *C*, 18 cents.

Now by an expenditure of a large amount of capital, the length of *A* is reduced 10 miles. The freight rate remains the same, as it is regulated by competition and other outside influences that have nothing to do with the length of the line. Dividing this rate proportionately to the new lengths, *A* receives 40 cents, *B*, 30 cents, and *C*, 20 cents.

That is, *A* loses 5 cents on every ton of freight, *B* gains 3 cents, and *C* 2 cents, when *A* reduces its length 10 miles. To look at the other side of the question, suppose

A to be 60 miles, B, 30 miles, and C, 20 miles, the rate remaining the same. Then the proportion would be: A, 48.6 cents; B, 24.3 cents, and C, 16.2 cents, showing an increase for A, with its increase in length, and a corresponding loss for B and C.

From this we see that that road will make the most money that forms the longest part in the shortest through line between any two points.

Suppose the whole line, however, belonged to A, and the rates were still fixed without regard to distance, the more A could reduce its length the better.

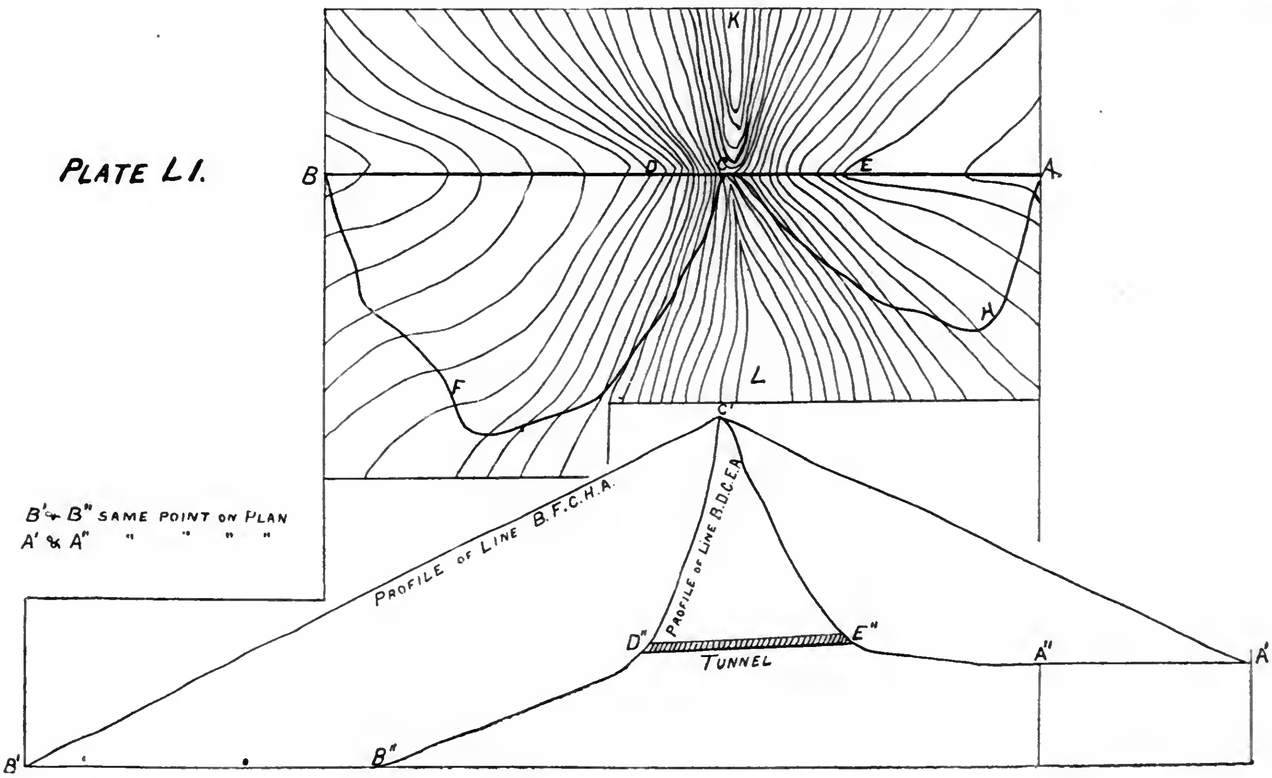
In some cases, however, even when A is only a part of a trunk line, it has received the same proportion of the receipts after its length has been reduced that it did before, on account of the gain to the line as a whole from this decrease in length. This is called "constructive mileage,"

With the limited amount of available capital we may locate the best possible road between the terminals that can be built for the money, using such curves, grades, and length as shall best suit the topographical features of the country, within the limits of the allowable expenditure.

If this road runs through a rough, mountainous country, it will have sharper curves, more of them, steeper grades, and greater length than would be necessary were it possible to expend more money. In most cases it will be found that the alignment and profile of the road could be very much improved with no increase and often a great decrease in the cost of construction, for the greater part of its length, provided it were possible to vastly increase the cost of construction at some few points.

Of course the total cost of the railroad would be very much increased. Thus, suppose we have the terminal

PLATE LI.



and whether A will receive it or not depends in the majority of instances not upon the merits of the case, but upon the power of A to enforce its claims.

Under any circumstances, however, it is true economy to reduce the curves and grades as much as possible.

In building a new road (particularly in a new country) the amount of capital available for the enterprise is often very limited, and even if this is not the case, the amount of future traffic is problematical, and it is not justifiable to go beyond a certain reasonable amount of expenditure in order to reduce the curves, grades, or distance.

What this amount may be is fully set forth in Chapter XXV. But the amounts obtained there simply give the values of these changes for some assumed or definite amount of traffic, or at least a definite number of daily trains. But in many cases where the probable or possible number of daily trains is very large, so that economically a very large absolute amount of money may be spent for each degree of curvature or foot of grade saved, it is impossible to obtain this amount of money at any reasonable rate. We then have two courses open in regard to the railroad.

stations so situated that there is a range of mountains between them. The railroad between these points may be located in either of the following ways:

1. The road may be located as a surface road—that is, one where the grade line is kept as near the surface of the ground as possible, thus doing away with any cuts or fills, or any heavy and expensive work. In order to locate a line of railroad such as this, doing away with all heavy work, or at least keeping the cost of construction per mile within certain limits, we must use a much steeper ruling grade, much sharper and more numerous curves, and a great increase in distance.

Thus, in Plate LI, let $K\,C\,L$ represent a range of mountains, and $A\,B$ the terminal stations, C the narrowest as well as the lowest part of the range. In order to locate a surface road from B to A, it is necessary to swing to the right or left of B, and climb the slope of the mountain at a greater or less angle to the contour lines, depending upon the angle of slope of the surface and the rate of grade that is being used, in order to be at such an elevation when C is reached that a deep cut will not be required. In locating a line such as this, the pass C would

be the proper place to commence the work. Decide how much cut can be afforded there, and what the rate of grade within certain limits shall be. Then, dropping both ways from C, find an approximate surface line that has the required rate of grade (much less than what is to be used as the ruling grade, as the compensation for curvature must be taken out afterward), and with this line get to the terminal stations in the shortest distance possible. When this surface line has been plotted with all its angles (usually no curves are run in on this first line), then locate a line on the paper as nearly identical with this surface line as possible, when the angles in the broken surface line are replaced by curves of a radius sufficient in length to permit the running of trains around them. Unless the distance between the terminal stations be enormously increased, the ruling grade on both sides of the pass will be very steep and the curves in all probability very sharp.

The road will cost comparatively little to build, but will be very expensive to operate. If the future business of the road is to be light, this is of slight importance, as from necessity there will be a certain number of trains each way per day without reference to the amount of traffic, and they will therefore be light, and can be taken up the heavy grades.

But in case the business of the road should at any time so increase that a large daily tonnage must pass over the road, a steep ruling grade would, as we have seen, so increase the operating expenses as to do away with all possibility of dividends.

Now a road located as the above could not in any way be materially improved as to its profile and alignment without an immense and most unjustifiable outlay of money to reduce the ruling grade, or else by abandoning almost entirely the original line and building a new one. The profile of the surface line is $B' C' A'$—that is, a uniform rise from B to C, and a uniform fall from C to A.

2. The other manner in which the road could have been located is as follows: Instead of endeavoring to get a uniform grade, with comparatively light construction, which we have seen necessitated a high ruling grade, sharp curves, and increased length, we start from B and run directly for C. By keeping in the valley we get light work, few curves, and for a certain distance, say to D, a very light grade. On the other side of the pass we have the same alignment from E to A. The profile of this line is shown at $B'' D'' C'' E'' A''$, and at D'' the ground begins to rise very rapidly to C'', and then falls as rapidly to E''.

The horizontal distance from D'' to E'' is very little, but the rise and fall to be overcome is much greater than it is possible to surmount by any trains and locomotives that can be economically run over $B'' D''$ and $E'' A''$.

If there is sufficient available capital, and the business of the road will warrant the expenditure, a tunnel should be run from D'' to E''.

This would require, however, a great increase in the amount of time needed to finish the construction. The better way would be to run the line from B to D and from E to H, getting as low grades and as perfect alignment as possible. Then from D to H build a temporary road over the pass as cheaply as possible, and operate it as a separate division by one or the other of the various methods that will be described.

Then, when the resources and business of the company make it advisable, build the tunnel $D'' E''$. When this is done all the road from B to D and E to A will be utilized, and the only portion that will have to be abandoned is the cheaply built, temporary road over the pass $D C E$.

Another case may and often does arise where it is advisable to build the temporary line in the first place, even when the business and resources are such as to make the building of the tunnel justifiable, and that is in order to gain time.

It frequently happens that a great advantage may be secured to a new road if it can be opened by a certain time, as when other competitors are trying to reach the same point. It may also happen that a large part of the road is completed, and that the tunnel section alone remains unfinished; here the interest on the capital invested in building the remaining portion of the road, which will accrue during the time which it will require to build the tunnel, may exceed the cost of the temporary road. This may very easily be the case, as in the latter instance the whole road as built is lying idle, and the interest on the cost goes on; but the whole road is made a paying investment by the comparatively small extra outlay necessary to build the short temporary line.

All that has been said in regard to a railroad crossing a mountain range by means of surface lines, tunnels, or temporary lines applies with equal force to crossing a deep valley or cañon. The only difference is that a high bridge or viaduct is substituted for the tunnel.

CHAPTER XXXI.

DEVELOPMENTS AND SWITCH-BACKS.

These temporary lines my be constructed and operated in various ways.

1. By means of additional engines or ASSISTANT ENGINES such a grade can often be obtained on the temporary line that all the freight that can be hauled to the foot of it by one locomotive can be taken up it by means of two or three. These extra engines can be put on to the original train, and it taken up the grade as one train, or it can be split into two or three trains, each one taken up separately. The only points to be studied in such a case as this are that we know in general terms what class of locomotives and what weight of trains will be on the main line, and also from the reconnoissance what probable rate of grade may be obtained on the temporary line.

We also have some general estimate as to the probable amount of future traffic, and we must also know what will be the cost of operating each assistant engine necessary.

From a combination of the different points of information we can decide how many extra locomotives and how much the gain would be to the road by this method of operating; also what the maximum allowable ruling grade of the temporary line may be.

This method of surmounting considerable elevations is capable of much expansion beyond the narrow limits to which we have confined ourselves in the foregoing chapter.

In the example we have taken, $D E$ is comparatively short, and the line for the use of assistant engines is merely a temporary expedient, to be replaced as quickly as time, resources, and business permit by a tunnel. But the same principle may be applied on a much larger scale and for permanent use. Thus, take a line of road 200 or 300 miles long, running through a country having such topographical features that any line of uniform grade would necessitate a high ruling grade. It would be much more economical, from both the operating and constructing stand-

points, to so locate the road that, if possible, all the heavier grades shall come in one operating section, making the ruling grade of this section comparatively steep, while the remaining sections preserve a much lower rate. By so establishing the grades on a road, all the engines are worked up to a point much nearer their total capacity, and on the section with the heavy ruling grade more engines can be used, and still every engine do its fair share of work.

Where the section with the steep grades is so short that it can be worked by assistant engines, helping up the different trains as they come along, one assistant engine can often replace three or four engines that would be necessary were the same altitude surmounted by a uniform grade.

2. The second method of surmounting considerable altitudes, where only the ordinary locomotive is to be used as tractive power, is by means of SWITCH-BACKS.

These may be and are constructed for both temporary and permanent use.

Where a definite weight of train is to be hauled over a line of road by a locomotive, the tractive power of which is known, the grades on that road cannot exceed a certain angle of inclination, and in order to surmount any elevation, by means of any required rate of grade, the only element necessary is sufficient distance.

The gaining of this distance required, in order not to exceed the maximum rate of grade, is called DEVELOPMENT—that is, running out of the direct course between the terminal stations *simply* to gain distance.

Where the topography will permit, the ordinary method of development is by swinging to the right or left of the direct line, fitting the line to the ground as closely as possible, and so meandering back and forth, always ascending at the required rate of grade until the required amount of distance has been obtained and the highest point passed. In this method the line as located is similar to any ordinary railroad line, being made up of tangents and curves, as shown in Plate LII, fig. 1.

In this location the curves must be of such a radius as to allow of the free running of trains around them. To run in curves of such a radius requires a certain amount of space, and to do this in the most economical manner requires a very broken and peculiar topography.

Some examples of gaining distance in this manner will be given in a future chapter.

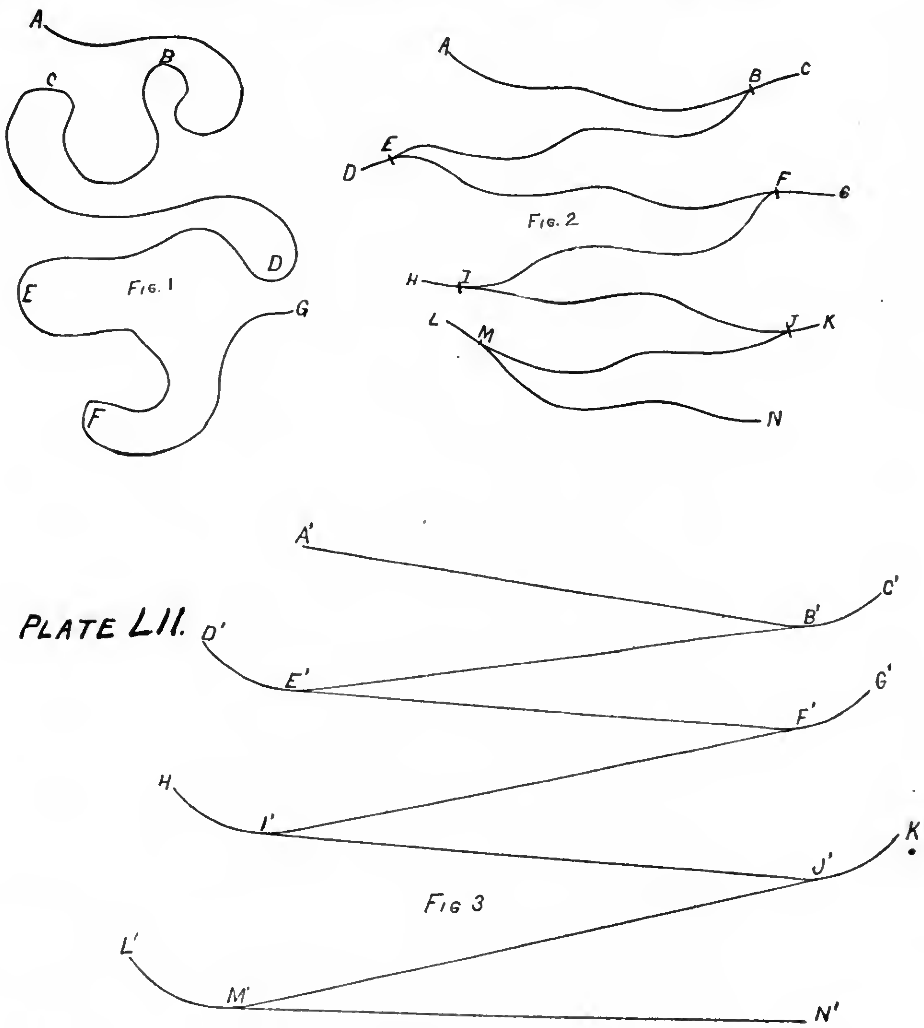


PLATE LII.

When, however, the line of road has to ascend the side of a mountain that is comparatively regular and uniform, so that there is no chance of developing to gain distance in the ordinary manner, the following expedient is often used, and could be used much oftener than it is if engineers would only put more time and study upon its many relative advantages, and the great gain both in time and money that may often be made by its adoption.

This method is what is known as a SWITCH-BACK—that is, the line of road, in being developed to gain distance, does not curve back and forth, as shown in Plate LII, fig. 1, in such a manner that trains can be hauled in one direction over the whole length, but zigzags in the manner shown in Plate LII, fig. 2.

In this we will suppose the road is located from N to M, upon the maximum grade; at M the direction is simply

reversed, and the road from M to J has the maximum grade, then from J to I, I to F, etc. In this manner as much distance may be gained as is necessary, and no more space is required than the width of the road-bed, plus any excess due to cuts or fills.

In this manner a railroad may be located in a most economical manner in regard to construction in a most difficult country. In regard to operating expenses it can at once be seen that trains cannot be run over switch-backs as economically as over a spiral, a series of loops, or any of the ordinary forms of development surmounting the same height with the same grade, from the fact that at every change of direction in the switch-backs, as M, J, I, F, E, the train has to come to a full stop and the direction in which it runs is reversed.

This reduces to a great extent the speed at which trains can be run over the road, not only from the time lost in stopping, but also because the trains can only be run at a limited speed between the switches.

In locating switch-backs, the following points must be studied: The maximum rate of grade having been established, and the line laid out on that grade from A' to B', etc., as shown in Plate LII, fig. 3 (see fig. 2, which is a profile of the line), a train running from A' to B' will run down by the force of gravity alone, and at the foot of the grade B' will have a certain amount of velocity; the amount of this velocity will depend upon the number of vertical feet through which the train has passed, provided this vertical distance is not so great that if the train is allowed to drop the whole distance without restraint, it will acquire a velocity greater than the allowable maximum for safety. In this latter case the brakes are applied, and the speed at no time allowed to exceed this maximum. From this we can calculate that all trains will arrive at the foot of the grade or at the switches at approximately the same speed, and consequently that the same amount of force per ton of weight will be required to bring them to a stand-still. The most economical and practically the best method of doing this is to extend the track beyond the switch, with a gradually increasing up grade, until it becomes sufficiently steep and long to bring the train to a stand-still by means of the resistance due to this grade.

The reverse in the direction of the grade from down to up at B', E', F', etc., must be made by means of a vertical curve, the point of the curve, which has a horizontal tangent, being at the switch, as at B' E', etc., and the grade rising each way toward A' and C, and D' and B. From the switch B' in the direction C' for a distance greater than the greatest length of train, the rate of grade must not exceed the maximum. In order that trains ascending may be able to clear the switch without trouble, the rate of ascent beyond this point can be very much increased, and up to a certain limit the more the better. The proper establishment of this stopping grade is an extremely simple matter, and requires only a careful study of the chapter upon the Effect of Velocity upon the Movement of Trains. By an application of the principles there explained, we can estimate at once the exact number of vertical feet rise necessary to bring the trains to a stand-still. The horizontal distance that shall be employed to obtain this amount of rise depends within certain limits upon the topography of the country in each particular case.

Wherever possible (and we may say that where switch-backs are advisable it is always possible) switch-backs should always be located in pairs, with the distance between any pair as short as possible.

The reason of this is that a train either ascending or descending has to run backward after passing one switch-back until it has passed another. There are many objections to this in the practical rapid running of trains. One of the most important is that unless the locomotives used are of special construction for the purpose they cannot with safety, speed and economy run backward over sharp curves.

Another point that is indispensable to the economical and rapid operation of switch-backs is that the switches should be perfectly automatic, or, better still, that the locomotive driver should be able to set them as he chooses from the locomotive while it is in motion. They should also be so arranged that in case of a runaway or a loose car coming down the grade the car can pass the switch without any danger of derailment, and also that the switch shall remain set in such a manner that when the runaway has been stopped and returns it will not run down to the next switch, but simply run back on the same track it came down on, and thus be brought to a permanent stop. As this stop will usually be upon or near the switch, and for many other obvious reasons, care should always be taken to so locate the switches or the track leading to them that they can be seen for a sufficient distance on either the up or down grade, to permit of the trains being stopped by use of the brakes in case the line for any reason is obstructed. Of course the distance required for stopping a train is much greater on the down grade, and much more care and money can be expended to make the switch visible for a long distance from the down grade track than would be justifiable upon an up grade approaching the switch.

There are very few examples of switch-backs in permanent use, as there are undoubtedly many disadvantages connected with their use upon roads of large traffic, but for temporary expedients for passing great elevations they are of invaluable assistance to the engineer.

Some examples of the most noted switch-backs, both for permanent and temporary use, will be given in a succeeding chapter in connection with examples of spirals, loops, etc.

The advantages of switch-backs are as follows: A reduction in the number of degrees of curvature, and a great decrease in the cost of construction. The amount of curvature can usually be reduced to one-half or less of what it would be in surmounting the same elevation by the ordinary system of development, and in many cases the cost of construction can be reduced in a similar proportion. The distance required to surmount a given elevation by means of a given rate of grade is also less on any line that reduces the amount of curvature, as the rate of grade has to be reduced for each degree of curvature, and consequently more distance is required to surmount the same elevation. This, therefore, makes a saving in distance in the use of switch-backs.

By far the most important gain made by the use of switch-backs, however, is in the first cost of construction.

The other two advantages named—reduction of length and curvature—are more than offset by the disadvantages—namely, more or less danger, loss of time, and the general inconvenience attending any attempt to do a large and rapid business.

(TO BE CONTINUED.)

NOTES ON THE SEWERAGE OF CITIES.

(Translated from paper of M. Daniel E. Mayer, Engineer, in the *Annales des Ponts et Chaussées*.)

(*Continued from page* 358.)

IX.—THE COST OF A SYSTEM OF SEWERAGE.

THE dimensions and consequently the cost of a sewer depend on two elements, the quantity of water to be carried and the available fall.

Everything else being equal, the expense of a system to carry off the waste water from a city will decrease as the general topographical conditions permit us to adopt greater degrees of fall. However, we are not obliged to believe that in cases nearly alike the variations from this cause will be very important. If we designate by r the radius of a pipe sewer, or one-half the greatest width of an ovoid sewer, the capacity for carrying water is proportional to $\sqrt{r^5 I}$. If we double I we diminish r only by 15 per cent., or if we triple I we diminish r only 25 per cent. Now, both in the case of the masonry sewers and pipe sewers the first cost increases a little more rapidly than r, but much less so than r^2, so that when the average fall in different cities does not attain exceptionally large figures the variation in the size and importance of the works will not be very great.

The expense of the establishment of a system of sewers per inhabitant will depend on the density of the population, and will have a tendency to increase as that diminishes.

As an example, we will compare the length of sewer in two cities of unequal density of population, the ordinary duty being in proportion to the density. As to the rain-water, it is making a hypothesis favorable to the city of less population to assume a reduction in the volume of these waters proportional to that of the ordinary duty, resulting from the smaller proportion of the surface paved or built upon. It may be noted, however, that it is usually the case that where the density of population is less the proportion of surface built upon will be somewhat greater, because the houses will be generally smaller and of fewer stories.

The same length of sewer should, on these assumptions, have in two cities a capacity for carrying water in proportion to the density—that is, to the number of inhabitants per hectare, which we may designate by N. Then for the same value of I, N will be proportional to $\sqrt{r^5}$—that is, r will be proportional to $N^{\frac{2}{5}}$; therefore we will not go contrary to the result of experience in assuming that the expense to construct a sewer will be proportional to $r^{\frac{5}{4}}$. We will see then that the expense of an equal length of sewer in two cities will be approximately proportional to the square root of the density, and the expense per inhabitant inversely proportional to the same square root.

This proposition, although it is only an approximation, is interesting as showing us that if we wish to render possible the construction of a complete system of sewers, even in small and moderate-sized cities, where the population is generally less dense than in large cities, and in which the resources per inhabitant are less, we will meet with financial difficulties which can only be surmounted by strict economy in design and construction.

However little we depart from these principles, we will reach in certain cases some exceptional results. I recently had in my hand a plan for sewers which had been prepared without any reference to the department of Ponts et Chaussées for a provincial city of 55,000 inhabitants, where the annual revenue was somewhat less than 1,500,000 francs; the system would not have cost less than 5,000,000 to 6,000,000 francs, without counting the cost of maintaining the large galleries and the expense of cleaning them out.

If modern hygiene were only attainable at such a price we would be obliged to do without it.

Happily it is possible, by following the principles which we have indicated, to avoid such excessive cost; by exercising careful economy in small cities and by limiting also in certain points subterranean carriage for rain-water, we will usually be able to establish a proper system for disposing of waste water at a cost which may be provided for by a moderate tax.

The example of Berlin, where the density of population is much greater than in a city of moderate importance, and where, on the other hand, the topographical conditions are extremely unfavorable, permits us to indicate an average figure of 30 francs per inhabitant. This does not include the house connections, which must be paid for by the owner.

This first cost corresponds to an annual charge of 1.50 francs, which will perhaps be doubled by the cost of erecting the machinery intended for the purification of water at the point of discharge. Sewage water, owing to the fertilizing properties which it contains, represents a very considerable agricultural value, and it will in time probably be the case that the payment for the use of this will be a considerable item in the income of a city; but in the present actual state of affairs it is most prudent to assume that the city will bear the charge of carrying these waters to the places where they may be used for irrigation, and will deliver them to the farmer without cost or at a very low price.

It will be natural that, considering the many demands upon its resources, the municipality will seek to regain part of the cost of sewers by special taxes or assessments.

Certainly, in our opinion, such charges will be justifiable even for the service to public health only; for this kind of progress constitutes a real value, even from an economic point of view. But it is always to be feared that this value, difficult to determine, and especially to express in money, may be misunderstood by part of the public.

In order that new taxes should not be unpopular, they should be presented as a compensation for some service rendered, which can be valued in money. This will be the case if the system receives excrementitious matters. In fact, by this arrangement the cost of privy-vaults will be suppressed and the builders of new houses will not have to make vaults or cess-pools, and those which already exist may perhaps be used for other purposes. In this case we have not a vague contingent progress, but an evident increase in the value of the property. By this increase it will be easy to justify a system of assessments which will repay the municipality without resting too heavy upon the inhabitants.

X.—CONCLUSION.

Before closing these notes we must offer an excuse for having made such frequent use of examples taken from foreign countries. We fear the reproach of doing wrong to our French engineers by contrasting their practice as defective with the practice of foreign engineers. But this is not the truth.

The problem of which we have treated—a complete method or system for disposing of the waste water of an entire city—has not yet to our knowledge been treated in a single French city, with the exception of Paris, and the example of that city is, for reasons which we have indicated, to be admired but not imitated. The sewers which have been made here and there in the different provincial cities, chiefly for the purpose of disposing of the rain-water, cannot be treated in the same way as a complete system intended to dispose of the waste water. That is a problem which in France is new. Now English experience in this matter, although recent, is already considerable, and German engineers, who have so far simply applied English methods, have distinguished themselves by numerous and remarkable creations. It is necessary to refer to the experience and practice in these countries, not because they are the best, but because they are the only ones.

These new demands of sanitation tend more and more to become imperative in cities and to take place with the supply of pure water among the essential functions of the municipality.

Engineers, who are consulted in all questions of public works, have in this matter a great influence to exert, but this influence should be exerted in the interest of public health.

They must remember, however, that it is not only public health which must be considered; we must maintain on the other hand, in the plans and in construction, that strict

economy, which, in presence of the increasing demands of our time, is the only safeguard of municipal finance.

AN INDIAN BRIDGE OF BOATS.

(Paper by H. A. S. Fenner, Superintending Engineer, in the *Indian Engineer.*)

BEFORE describing the boat-bridges used in the Punjab, a brief description of the leading characteristics of the rivers will make their use more intelligible.

The chief rivers of the Punjab rise in the Himalayas: in consequence, early in April they commence to rise, due to the melting snows; and their volume, until the rainy season commences, varies entirely according to the climatic influences at work in the mountains. The melting of the snow, checked by night, sensibly influences the discharge for many miles beyond the debouche of the river into the plains. The rainy season lasts from about June 15 to the end of August, with occasional storms in September. The heavy floods generally occur early in August. As the rainfall in the winter months is comparatively small, the discharge of the rivers during the cold weather is quite insignificant as compared to that in the rainy season.

In the plains, the level of the riparian country is low, and the flood-water occupies a large area. In the cold weather the river is represented by numerous tortuous channels, some deep, some shallow, and the majority dry, utterly preventing the use of a ferry. Therefore, until the railroad necessities made bridging these rivers imperative, boat-bridges, from their portability and simplicity, were extensively used.

Perhaps the best example of this peculiarity is that of the boat-bridge across the Indus at Dera Ismail Khan. In the rains the Indus at this place inundates a tract of country 25 miles wide; of course, at this season, a bridge of any sort is out of the question, and a ferry is used. In the cold weather—taking for example that of 1885—the bridge was in four sections, with an aggregate length of 3,448 ft.

The boat-bridge illustrated by the accompanying drawings is that over the Indus at Attock. Here the river is confined by hills on either side. In consequence, the depth and velocity of the river varies immensely. The average rise of the river above the cold weather level is 56 ft., and a rise, due to a landslip occurring in the mountains, has been recorded of 96 ft. above the same zero.

The Indus has now been permanently bridged by a very fine iron structure, carrying the railroad on the top and the road on the lower portion of the girder, so that the boat-bridge is not now used. When put up, it was sometimes in two sections, but generally one was sufficient, with a total length of about 1,200 ft. The bridge was usually kept up from September until the end of May.

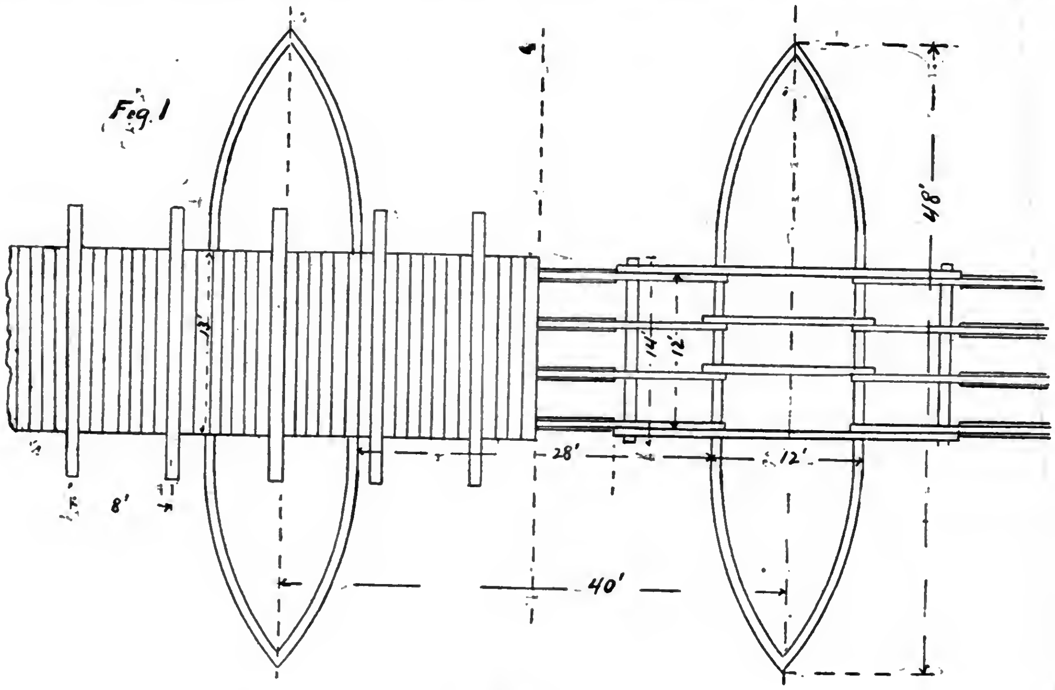
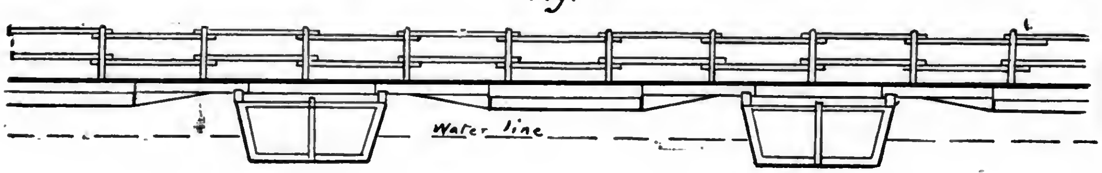
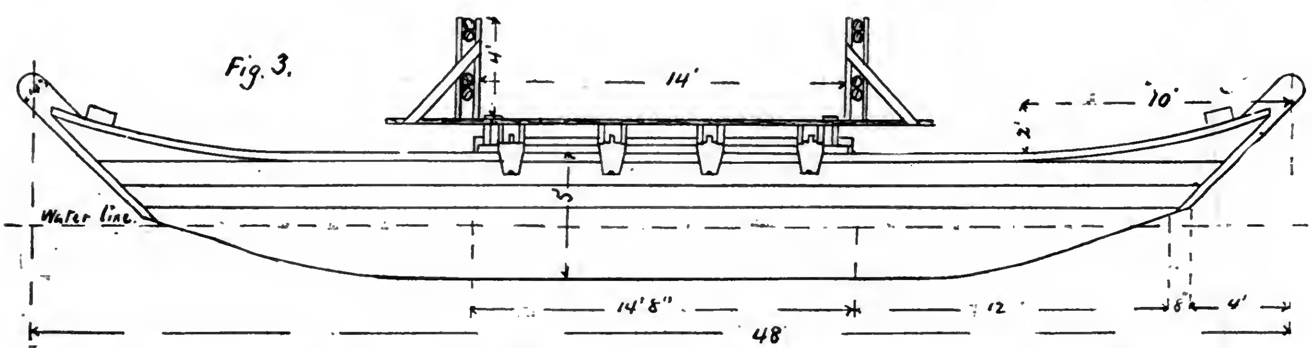


Fig. 2.

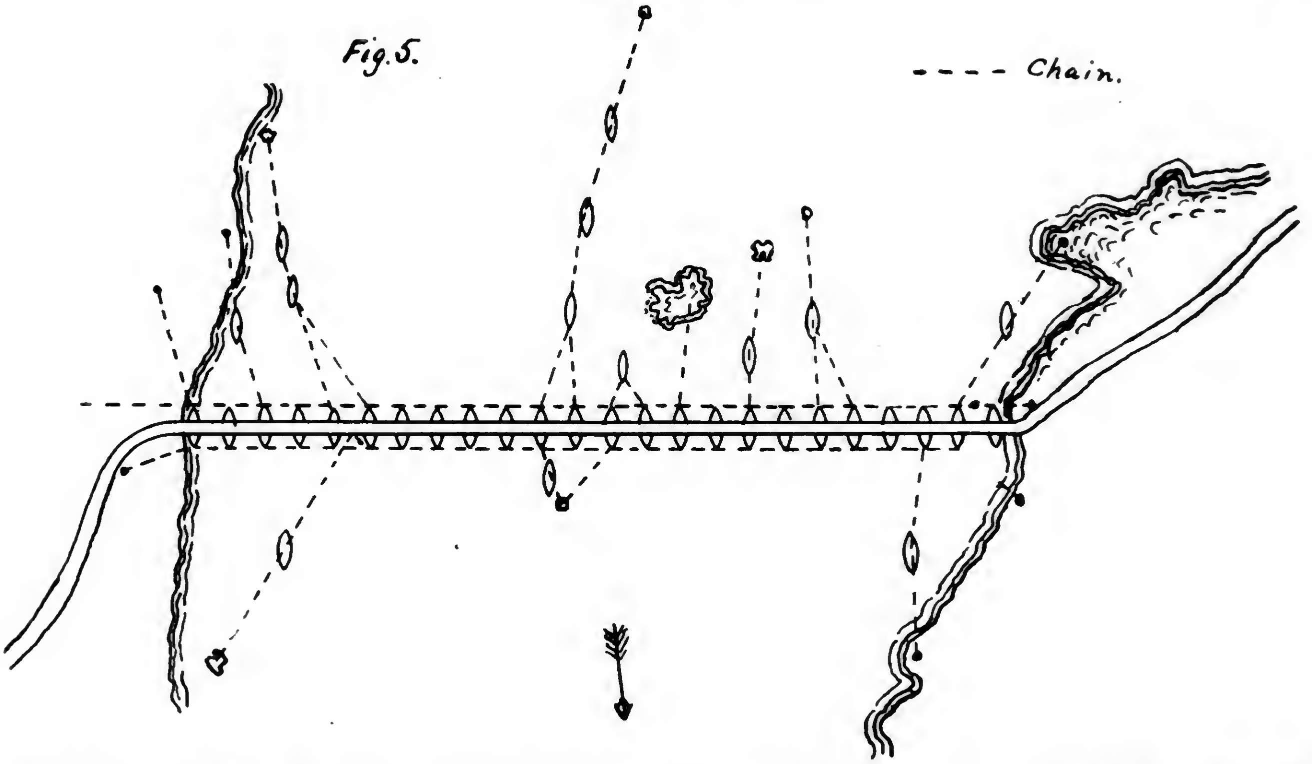




Of the accompanying sketches, fig. 1 is a plan of a short section of the bridge ; fig. 2 is a longitudinal section of the same, and fig. 3 is a cross section. Fig. 4 shows, on a larger scale, one of the trussed beams which carry the roadway between the boats. Fig. 5 is a map showing the location of the bridge and the arrangement of the anchors ; in this the anchor-chains are shown by the dotted lines.

In constructing the bridge the main cable is, in the first instance, got into position by means of smaller cables, fastened to the rocks or to piers purposely built, and is buoyed by ropes anchored at intervals. When this is secured, the boats are gradually got into position, commencing from one bank. As the boats are placed they

Fig. 5.



are kept apart, as shown in the plans ; they are anchored and other cables are laid until the bridge is safely secured, after which the roadway is laid. Cables and anchors are added as the state of the river demands, and if it is necessary to keep the bridge up after the river has attained a certain level, as was the case during the last Cabul War.

The bridge illustrated is shown in a straight line, but it has been found best to allow the bridge to assume the outline, in plan, of a catenary curve ; the advantage is obvious.

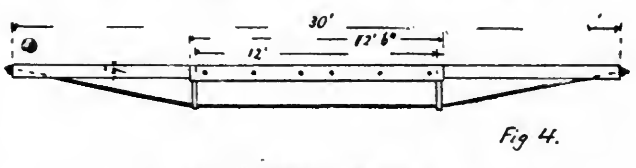


Fig 4.

Temporary roads to boat-bridges across the dry river beds are inexpensively made by laying down coarse long grass, usually found by the river itself ; on this sand or clay, if obtainable, is thrown, and the traffic speedily consolidates it.

Anchors of European manufacture are used, especially in such streams as the Indus, but rough anchors are often made and used, which are both effective and cheap, and which can be simply abandoned when the bridge is taken down on the river rising.

These bridges are expensive to maintain, though the first cost, as compared with that of a permanent bridge, is small. In the case of a river liable to sudden small floods, a number of experienced men are necessary to take needful precautions to prevent the bridge being swept away.

SPECIFICATIONS FOR A BOAT.

General.—The boat which is shown in the accompanying sketches has an extreme length of 48 ft., and breadth 12 ft., and depth midships 5 ft.; a tie-rod, running fore and aft, stiffens it against strains due to grounding.

Floor planks.—The outer floor planks to be $2\frac{1}{4}$ in. thick, the others $1\frac{3}{4}$ in. The planks not to exceed 12 in. in width. Each plank is to be secured to the floor beams by two iron spikes $\frac{3}{8}$ in. square and 7 in. long, the centre plank, and none other, is to be thickened toward the stern and sternpost up to 3 in.

Floor beams.—To be 2 ft. apart, center to center ; provision to be made to pass the bilge-water under these beams.

Hull planking.—To be 2 in. thick throughout, excepting in the curved part near bow and stern, where they may be reduced to $1\frac{1}{2}$ in. The planks not to exceed 9 in. in width. Each plank is to be secured to every rib it crosses by two square spikes of soft iron riveted up to washers. Each spike is to be tapering, to be $\frac{3}{8}$ in. square near the head. Twisted spike nails to be used for securing the ends of the planks to the stem and stern-posts. Each of these nails to be 7 in. long, and $\frac{3}{8}$ in. square, and with only one turn or twist ; the spikes are not to be less than 4 in. apart. Ordinary spike nails $\frac{3}{8}$ in. square, and placed 5 in. apart, to be used to secure the bottom side plank to the outside bottom plank.

Ribs.—To be of deodar wood and to be placed 2 ft. from center to center. An iron knee, $\frac{3}{8}$ in. thick, is to connect each rib with the floor beam on which it rests. This to be secured by six spikes of iron $\frac{3}{8}$ in. square, which are to pass entirely through the wood-work and riveted up to sunk washers. The ribs simply rest on the floor beams, no joint of any kind being used ; all ribs are to be 6×3 in.

Gunwales.—The longest timber procurable should be reserved for the gunwales and the first side plank below it, which should break joint with each other. The pieces of timber forming the gunwales are to abut against each other with plain square heads, and are to be secured with two straps of iron 2 in. $\times \frac{1}{2}$ in., and 6 ft. long, countersunk into the wood and bolted to it by six bolts $\frac{1}{2}$ in. in diameter. A 9-in. spike, $\frac{3}{8}$ in. square, is to secure the gunwales to each rib.

Deck beams.—Each deck beam is secured to each rib by two spikes of soft iron $\frac{3}{8}$ in. square. In the undecked portion of the boat a deck beam will not be required at every

pair of ribs. Two stout deck beams 6 × 6 in. are to be secured both to ribs and gunwales by rivets of ½ in. diameter; all other deck beams are 7 × 1½ in.

Cross beams.—Two are required, each 8 × 4 in., and are to be secured to the vertical props by ½ in. diameter bolts.

Vertical props.—Two are required, one at each angle of the tie-rod; each is to be 5 in. square; each prop is secured to the floor beams by two clinched spikes; each stands fair over the floor beam, which is not to be in any way cut.

Deck planks.—To be 1 in. thick, secured to each beam by two 3½ in. nails. The center of the boat is open. The deck only extends 8 in. from each end. A hatchway is left over the stem and stern-post knees, as shown.

Knees for stem and stern-post.—Each knee is held in position by three bolts ⅝ in. in diameter.

Stem and stern-post.—To be grooved to receive the ends of the planks, as shown. For mooring purposes an iron clip and key is to be fastened to a cross piece, which is secured to the gunwales and gunwale bracket by bolts ½ in. diameter.

Tie-rods.—There is one longitudinal tie-rod to each bolt of ⅝ in. diameter; it is made in two pieces, coupled under one of the decks by an iron coupling. The two ends of the tie-rod are secured behind the knees at the stem-post and stern-post by iron keys 1 in. wide and $\frac{5}{16}$ in. thick, which pass through them and rest on light washers, the ends of the keys being split. There are also two cross tie-rods ⅝ in. diameter, one above each cross beam.

Painting and Tarring.—The bottom of each boat outside, as also the sides outside, to a height of 1 ft., to be tarred. The sides above the tarred part, both inside and out, and the gunwales, are to be painted in three coats of lead and oil; the first coat is to be of red lead, the second of white lead.

Wood.—All knees, stem-posts and stern-posts to be of the best seasoned hard word, Shisham (*Dahlbergia sissoo*). The rest of the wood to be seasoned deodar. (*Cedrus deodara*).

Cost of Boats.—In each boat there are 234 cub. ft. of wood-work, 857 lbs. of iron-work, 434 sq. ft. of tarring, and 1,300 sq. ft. of painting; and the cost of such a boat would be about 800 rupees ($286) on the Punjab rivers.

English Armed Cruisers.

(From the London *Engineer*.)

DURING the last few years we have been told to comfort ourselves in that while our recognized navy will be competent to deal with the fighting ships of an enemy, we have a large reserve in the shape of armed merchant vessels, which would be able to protect our ocean routes from the *Alabamas* that a hostile Power would naturally equip to harass our immense floating trade. This was a happy idea on the part of the Admiralty, one eminently calculated to soothe the public mind. There was a sense of protection and security conveyed in the very name of "armed cruisers," of which the naval administrators knew how to take advantage. Accordingly we were told that arrangements had been made with certain owners of mail steamers, by which the best and fastest of their vessels might be taken up in time of emergency, fitted with guns, and sent out to protect the ocean highways. In theory this was really an invaluable proposal, which seemed to lighten the burden of anxiety resting upon the hearts of all true lovers of their country; but theory will never save us from ruin, so we propose to consider a few practical points in regard to the merchant cruisers.

We all remember the Russian scare of 1885, when first these vessels were taken up seriously, and we remember the time that elapsed before even one of them was in a condition to set out on a war-cruise—the *Oregon*, in fact, being the only one of all those taken up which was completely equipped for the purpose intended. We will assume that since definite arrangements have been formed for what might be called a standing fleet of cruisers, due preparations will be made and stores and fittings will be at hand to equip them with the least possible delay, so that they will be ready within, say, a week of their arrival at a home port, and, allowing also that the destinies of England will not be decided in so short a space of time, we will proceed to review what material we have before us in the shape of the vessels.

On reference to Lord Brassey's "Naval Annual," we find under the heading of "Royal Naval Reserved Merchant Cruisers," 19 vessels at present afloat, ranging in size and speed from the *Umbria*, of 7,718 tons and 18½ knots, to the *Celtic*, of 3,867 tons and 14 knots. There are also two new White Star boats of 10,000 tons, which appear upon the list, but they are not to be completed until about August, and as they present features quite novel in the history of merchant shipping, we will treat them after the other vessels of the Reserve have been dealt with. Lord Brassey lays down as a law that "exceptional strength and speed are the only desiderata" in this class of vessels. We here beg leave to elaborate these simple conditions roughly into the following:—Structural strength, minute subdivision into water-tight compartments, invulnerability of the vital parts, great stability, so as to offer a steady gun platform, capability of being easily and promptly handled, and a speed that will enable them to outstrip any enemy of a nature too formidable to be fought. Let us, then, examine the vessels under consideration, and see in what degree they comply with the above necessary demands upon them.

We saw a year ago how two of these steamers touched each other in mid-Altantic, with the result that one had her bows torn away, while the other had a huge hole cut in her side between wind and water, and nothing but the noted attention paid to the bulkheads of White Star liners prevented an awful double disaster. We were all startled to hear that the *Oregon*, then on the list, had been run down by a schooner, and it is but natural to ask in what respect the surviving vessels are better than she was. Some of them, in that they are built of steel, do possess a decided advantage over her; but as to subdivision into water-tight compartments, we find that none of them boasts of more than nine bulkheads, while most have but seven or eight. The nine bulkheads of the *Oregon* did not prevent her from foundering. The final plunge was certainly postponed during eight hours, so as to insure the safety of the large number of souls on board, but down she went at last; and if she had been fitted with only so many bulkheads as some others of these cruisers, she would not have floated so long. Next as to the protection of vital parts. We take it that the vital parts of a cruiser would be the rudderhead and steering gear, the boilers and engines and funnel casings, and the conning-tower or wheel-house. To the question as to whether these parts are adequately protected in our merchantmen, the answer is self-evident to every one who in any way understands their construction. The exposed position of the steering gear is in itself an insuperable difficulty, seeing that the rudderhead quadrant is situated from 10 ft. to 20 ft. above the water-line; while it is questionable whether any amount of coal armor would properly preserve the boilers and cylinders, the latter especially being nearly always above the load-line of the vessel.

With regard to the fighting powers of the cruisers, it is a matter of doubt whether these vessels are constructed with sufficiently heavy scantlings to be able to fire with impunity the guns with which they would be fitted, while an attempt to ram an enemy's ship, which would be a very reasonable feat to be expected of a cruiser—given the opportunity—could only be attended by consequences most serious to both parties. We do not ask that these converted mail steamers shall be able to withstand the projectile of a 110-ton gun or the spur of an armor-clad, but we do expect that our commerce protectors shall be capable of using their weapons of offense and defense without accomplishing their own destruction by so doing. The famous vessels on the list are to work wonders, but the authorities put the fact out of mind that the structural strength that experience dictates as necessary to resist the weather of an Atlantic passage is formulated on conditions very different to those of an action. Furthermore, the stability of a passenger liner is calculated so as to produce the easiest possible motion consistent with safety, a quality

which caused the *Oregon*, during the manœuvres in Bantry Bay, to be stigmatized by the naval officers as very crank, and therefore very unsuitable to act as a gun platform. An armed cruiser will simply be a useless incumbrance if she cannot work her guns with some degree of accuracy.

The capability of this class of vessel of being easily and promptly handled is a quality chiefly conspicuous by its absence. It is only natural that a vessel built of a great length in proportion to her breadth, say in the ratio of nine or ten to one, and furnished with only a single propeller, and a rudder none too large, should be deficient in turning power, as compared with a ship of war. The general design of the vessel is calculated for fast ocean steaming straight ahead, and is in no sense fitted for, or capable of, executing such sudden turns and twists as will obtain in an action with an enemy at fairly close quarters; and at close quarters the engagement will have to take place, in anything like a seaway, if either party means to cripple the other. Some people affirm that the stern is the only aspect of the cruiser which need be presented to a foe, in which case speed will take the place of other attributes; but we take it that these merchant cruisers are not subsidized to escape from the first foreigner who appears, but to protect themselves and any vessels of the same flag which may be with them from any enemy short of an ironclad. Our interpretation of a cruiser's functions being correct, it is evident that a slow turning vessel is of little use, for a much smaller and weaker boat, if readily handled, would soon give a good account of its more unwieldy adversary.

Then as to the question of speed, in which these cruisers are supposed to show so marked a superiority over war vessels. The 19 steamers already afloat, and therefore ready for service, average exactly 15½ knots at sea, according to the official reckoning, varying, as before stated, from 18½ knots down to 14. Where do these figures show a superiority in speed, as compared with the 19 and 20 knots unarmored cruisers of the French and other navies? Supposing one of our converted mail steamers to find herself while in the exercise of her protective duties anywhere within reach of one of these 19 or 20-knot vessels, where is that excess of fleetness necessary to carry her out of range of an adversary with which she is unfitted to cope? Even if we cut down the speed of the foreign cruisers by three knots as an average to be maintained at sea, they still show a knot to the good, as compared with the average of our so-called merchant cruisers. With regard to the two new White Star liners now building, we have already alluded to them as possessing features of interest distinct from and superior to those of the other steamers on the list. These two vessels are of about 10,000 tons gross, measuring 565 ft. in length, by 58 ft. breadth of beam, with twin screws, driven by two interchangeable sets of triple expansion engines. In addition to a good number of transverse bulkheads, there will be longitudinal bulkheads running the entire length of the ships, and extending above the water-line, an innovation of no small importance if the usefulness of the vessels as naval cruisers is to be considered. The steering gear, rudderhead, boilers, and engines are situated below the load water-line, the coal bunkers being placed abreast of the engines as armor. These are the chief points which at present are made known, and, even with this fragmentary specification, it is evident that these vessels mark the commencement of a new era in the history of mail steamers. They are calculated to develop a speed of at least 19 knots, which, however, according to past experience, may be considerably increased upon actual trial, it being highly probable that the late performance of the *Etruria* may be eclipsed most completely by these newcomers. So far as speed and construction go, these vessels may be accepted as fulfilling conditions suitable to their employment as cruisers, the only point against them being their excessive size, a point, however, which may be no disadvantage in actual service, especially if their huge bulk and length does not militate against the increased manœuvring powers afforded by twin screws. As transports, they are each stated to be equal to the task of conveying 2,000 men to Bombay in 14 days *via* the Suez Canal, or 22½ days *via* the Cape in the event of the shorter route being blocked.

Having thus briefly reviewed the more prominent failings of the present fleet of merchant cruisers, failings which should debar many of them from being included in the list, we now venture to submit certain conditions as absolutely requisite in any vessels which are to be intrusted with the responsibility of protecting our commerce. They are not, we consider, conditions of an impossible nature, although they may seem at variance with the present practice of shipbuilding; and we certainly are of the opinion that the Admiralty has no right to subsidize vessels in the future which are not built in accordance with some such regulation. Briefly then, the following represent our idea of what qualities the armed cruisers of the future should possess:

A hull built of steel of large scantling, with the bows especially strengthened so as to be able to ram, if necessary. In order to secure good manœuvring facilities for this purpose, the beam of the vessel should not be less than one-eighth of the length, and the fore-foot and all the deadwood astern should be shaped to this end, while the rudder should be considerably larger than is the rule with the present class of merchant steamers. As to subdivision, there should be a cellular double-bottom extending the whole length of the vessel, at least 15 transverse bulkheads rising to the upper deck, and a longitudinal bulkhead throughout the vessel's length, rising to the same height. No doors should be fitted in the bulkheads at a less distance above the load water-line than 6 ft. The engines and boilers should be placed well below the load-line, with the bunkers arranged so as to afford at least 10 ft. of coal armor against the sides of the ship; and each set of engines, and each set of, say, two boilers, should be placed in separate compartments. The funnels and uptakes and the conning-tower should be efficiently protected by armor-plates. The engines should be twin-screw, of the triple or quadruple-expansion type; and their parts should be interchangeable. The stoke-holes should be arranged for forced draft, but under natural draft the mean sea speed of the vessel should reach at least 19 knots per hour during a 96-hour trial. The supply of coal should enable the vessel to cruise for long periods at 10-knot speed, or for 10 days at 20-knot speed.

These latter considerations of speed and coal endurance stand pre-eminent among the requirements of an armed cruiser, and are the qualities which above all should be insisted upon before any steamer is subsidized in the future. How far it is possible to reconcile these conditions with those governing at present the construction of our great mercantile ships is a question on which we shall not enter.

NOTES ON STEAM HAMMERS.

By C. Chomienne, Engineer.

(Translated from the French, under special arrangement with the Author, by Frederick Hobart.)

(*Continued from page* 356.)

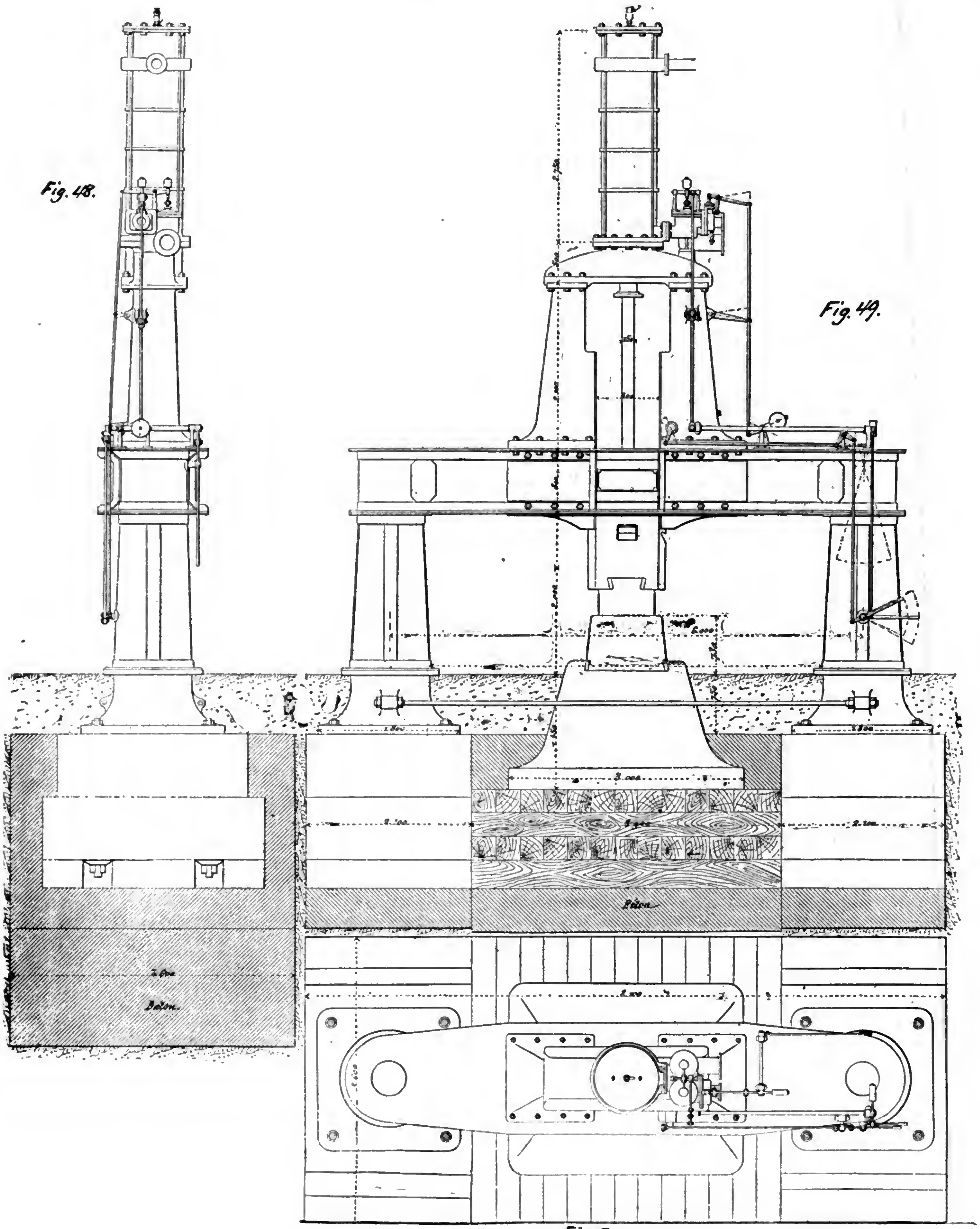
CHAPTER XIII.

THE HAMMER.

The form of the hammer should be as simple as possible; it depends exclusively upon its weight, its breadth, and the form of shoe or die which it must carry. Its height must be great enough to permit it to be guided properly at the moment of the blow, for the reaction of the hammer upon the guides often lead to a rupture of the frame, and this is another reason which makes it necessary to brace these frames strongly at that point. From this fact it also results that for the same play between the slides the inclination of the hammer in relation to the rod is less where the height is great, and consequently the rod is less subject to breakage.

Hammer-blocks are generally of cast iron or steel; a few are of forged steel or of wrought iron. Their form is usually a parallelopipedon. In cast-iron hammer-blocks there is often made above the key-way a recess intended to receive a wrought-iron ring, which is sprung on for the purpose of strengthening the head and preventing breakage.

The dovetails by which the faces of the hammer and the anvil are held on should be at right angles in every case where the frame is open at the bottom, in order to avoid the loosening of the shoes or dies, to hold them well opposite each other, and to do away with the risk of a glancing blow. usually that shown by fig. 46; sometimes, however, they are given the form shown in No. 2, fig. 46, especially in the case of hammers with wrought-iron frames (as, for example, the 100-ton Terni hammer), in order that the slides bolted to the legs, which are generally of wrought-iron



SINGLE-ACTING 5-TON HAMMER, FIVES-LILLE COMPANY.

Where the frame is single or not open at the bottom, these dovetails are necessarily in line with each other, because it would be impossible to drive keys for them otherwise.

The form of the hammer-block and the guides on it is plates and angles, may be made of as simple form as possible. The form No. 1 is the best, because it presents greater resistance and gives the hammer-block the greatest possible width, which is always a great advantage, as will be readily seen.

CHAPTER XIV.

HOLDING DOGS OR CATCHES.

All heavy hammers should be provided with holding dogs or catches, intended to keep the hammer in position when any one is working below, and especially when the shoes or dies are being changed; this arrangement insures

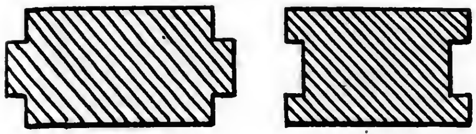


Fig. 46.

No. 1. No. 2.

complete safety to the machinist charged with the work below, and also saves steam, as it prevents leakage through the piston when the changes take some time.

Catches working vertically seem to me to fulfill their object much better than those working horizontally, considering the ease with which they can be operated; moreover, the strain upon them is that of compression and not a transverse strain.

In the 10-ton or smaller hammers a single catch is usually sufficient; beyond that weight it is better to employ two, which are held together by cranks so that they can be worked at the same time.

These catches should be so arranged that the hammerman may be able to work them, by means of a foot-lever or a hand-lever. For large hammers the foot-lever is preferable because it leaves both the hammerman's hands free to work the valves, and moreover there is not likely to be any confusion in working the levers.

The catch is fixed upon a horizontal shaft or axis, which is moved by an intermediate lever receiving its motion from

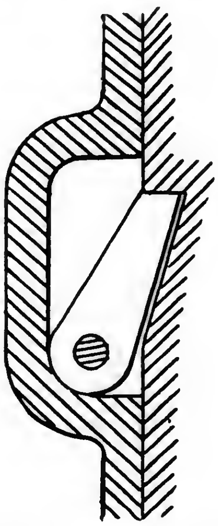


Fig. 47.

the foot-lever by means of a crank. The lower extremity of the catch should be concentric with the shaft and should fit well in the casting in which it is set, in order that the shaft may not be subjected to transverse strains. Under these conditions the catch alone does all the work and transmits the strain to the frame, the shaft serving only to cause it to move. A sketch of this arrangement is shown in fig. 47.

CHAPTER XV.

GENERAL REMARKS.

We have always considered it best to recommend the use of mineral oil for lubricating the pistons instead of tallow. The oil should be allowed to vaporize, or lubricate the steam, before its entrance into the valves. This method of lubrication is much more economical than tallow and also much more rational, because it is constant instead of intermittent.

We would also recommend the use of automatic escape valves placed immediately before the valve or the steam-port in order to free the steam from the water of condensation, which generally forms in considerable quantities in consequence of the irregular work of these tools.

In all large hammers it is necessary to place, at a certain height above the cylinder, two girders long enough to span the hammer completely and carrying a rolling crane. This crane will be found of great service not only in setting up a hammer, but also because it will enable a broken piston-rod to be replaced, or other repairs to be made, in case of accidents, more easily and quickly than without it. The crane known as the Mégy fulfills admirably the requirements for this purpose, and one can easily be made to serve several hammers if they stand in a line.

In steam hammers most of the parts are subjected to shocks, the intensity of which cannot be appreciated or exactly calculated beforehand, and for that reason, in designing a hammer, careful attention should be paid to what has already been done in this line, and the engineer should confine himself within the limits approved by experience.

CHAPTER XVI.

THE FIVES-LILLE FIVE-TON HAMMER.

The hammer represented in figs. 48, 49, and 50 is one made in 1885 by the Fives-Lille Company for the National Marine forges at Guerigny. Fig. 48 is a side elevation; fig. 49 a front elevation, and fig. 50 a plan.

This is a single-acting hammer with an independent anvil-block; it is of a construction as yet little used in France, but is remarkable for its good design. The proper proportions have been well observed in each of its parts, and they are the result of careful study.

We will not describe the foundations, for the drawing shows sufficiently well the care with which they have been made, in order to secure great stability for this tool.

The frame is composed of circular columns of wrought iron supporting a square box-girder of wrought-iron plates and angle-bars, upon which are placed the guides and which has in the center an opening just large enough to permit the passage of the hammer.

The guides are of cast iron and are fixed to the girder by heavy bolts; they are united at the upper end by the upper frame or table, which serves at the same time as a cross-brace to stiffen them.

On this upper frame rests the cylinder, to which is bolted at the lower end a steam-chest, the steam-valve being in front of the steam-chest. The distribution of steam is made by balanced valves with a double seat.

The hammerman is placed behind the columns on a level with the ground and has to move by levers:

1, The steam admission valves,
2, The balance valves,
3, The safety catch or dog.

The distance between the centers of the upright columns being 6 meters and the cross-girder being 2 meters above the ground, the anvil has abundant clear space around it, so that the forgings can be handled with much facility.

The principal dimensions of this hammer are as follows:

Weight of the working parts...	5,000	kilos.
Weight of the anvil-block.....	35,000	kilos.
Stroke of the hammer.........	2.000	meters.
Width of the hammer-block...	0.800	meter.
Diameter of the steam cylinder.	0.600	meter.
Diameter of the piston rod....	0.150	meter.

This tool answers very well for large forgings, such as stem and stern-posts, ship rudders, ship anchors, etc., and has thus far given excellent results.

CHAPTER XVII.

THE L'HORME TEN-TON HAMMER.

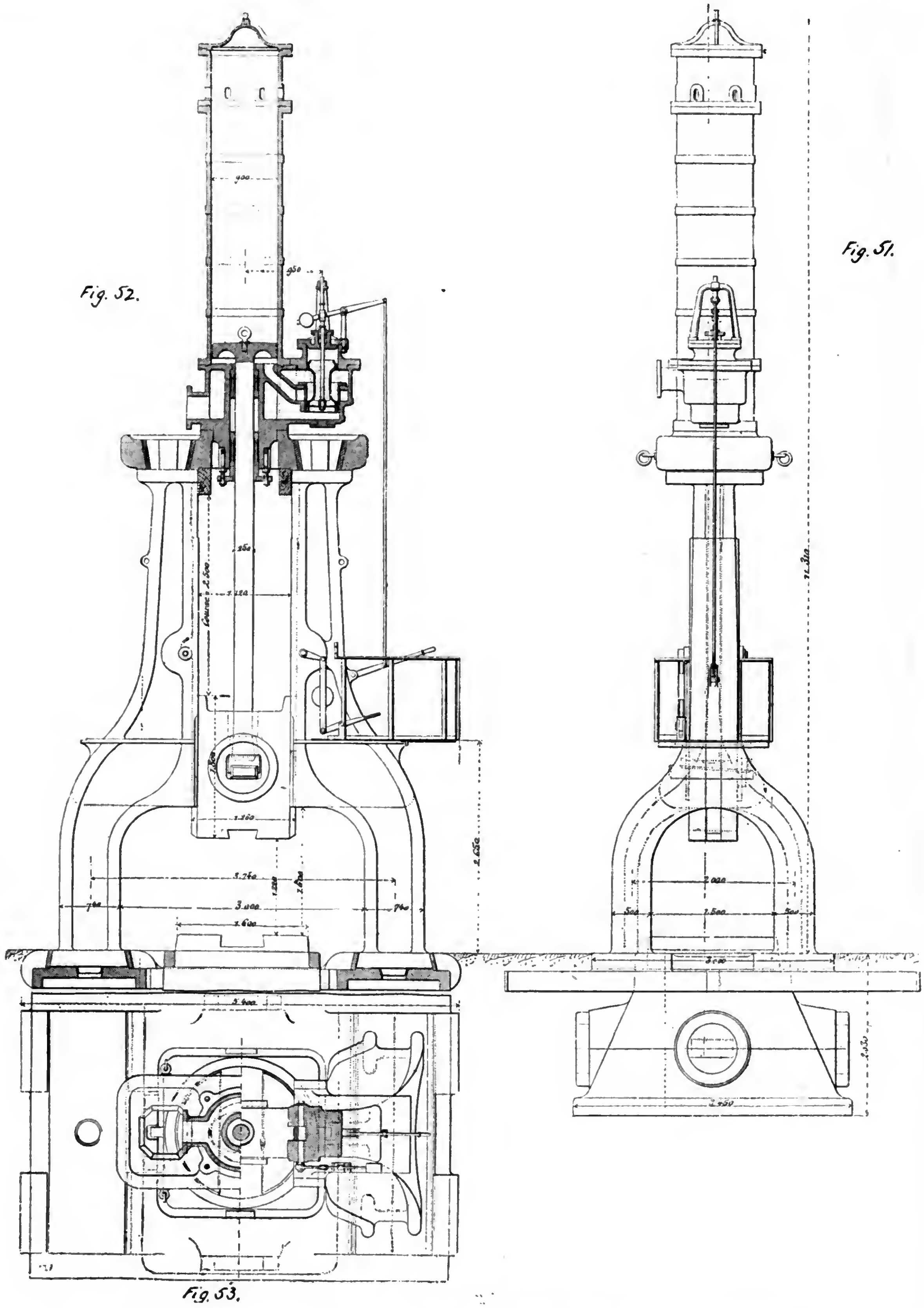
This single-acting hammer, shown in figs. 51, 52, and 53, was designed by the Compagnie des Forges de l'Horme for the Firminy Steel Works. It has many advantages which a hammer intended to forge heavy pieces should have. Fig. 51 is a side elevation; fig. 52 a front elevation, and fig. 53 a plan of this hammer.

The anvil, which is of unusual weight, 80 tons, has a very wide base. It is made in two parts, held together by means of four hoops, put on hot over hubs or lugs cast on the block. Between the two parts is a round block embedded or mortised into each piece one-half of its thickness, which is intended not only to cause the pieces to come together properly, but also to prevent any sliding of the

upper part upon the lower and to make them, as far as possible, as solid as if cast in one piece.

The upright frames or pillars are of I section, with proportions carefully worked out, and present a very great

The width of their base is 3.000 meters and the open height below the guides 1.800 meters, so that it will be seen that the forging will be very accessible and consequently easily handled.



SINGLE-ACTING 10-TON HAMMER, COMPAGNIE DE L'HORME.

resistance to shocks. At the lower end they are divided into two parts, leaving between them a clear space of 1.500 to 1.800 meters in order to permit the proper handling of the forging under treatment.

The pillars are keyed below to the cast-iron bed-plates on which they rest, and are centered upon those by pins cast in them. They are fixed above to the upper frame or table by keys made of heavy wooden blocks, which are

used in order to take up in part the shocks to the hammer.

The bed-plates on which the frame rests have a very large base, and are joined together inside and outside by small iron rings put on hot upon hubs cast on the face of the plate. They are set upon a large foundation of masonry and fixed in place by heavy bolts placed at each corner.

The distribution of steam is made by a cylindrical balanced valve 0.400 meter in diameter and having 0.140 meter stroke. The piston is of steel and is forged in one piece with a rod, which is 0.250 meter in diameter.

The hammerman stands in this hammer upon a small platform resting on brackets on the frame through the medium of angle plates, to which the floor of the platform is bolted. In this way he is clear from all interference with the men who are handling the forging, and is also relieved in great measure from the heat thrown out by the red-hot mass of iron or steel. This platform is 2.650 meters above the ground.

The cylinder, which is 0.900 meter in diameter, carries a safety apparatus on its upper end, as shown in the engraving; it is placed above and rests on the steam-chest, being fastened to it by bolts.

The steam-chest is made in one piece with the frame, but rests in the center on a cylindrical ring carefully finished and fitted, and is secured to the upper frame by four large bolts.

The hammer carries a safety catch which can be worked by the hammerman from his platform by a foot lever.

The dimensions of this hammer are as follows:

Diameter of the steam cylinder	0.900 meter.
Stroke of the hammer	2.500 meter.
Diameter of the piston-rod	0.250 meter.
Diameter of the piston-valve	0.400 meter.
Stroke of the piston-valve	0.140 meter.
Weight of the working parts	10 tons.
Weight of the anvil-block	80 tons.

The large free space given below, the long stroke of the hammer, the great stability of the frames, their great resistance to shocks, the elegance of their shape, the simplicity of the distribution of steam, the great weight of the anvil-block and its wide base enable us to say that this hammer is an excellent example of a tool of this class, and may be safely taken as a model for hammers intended for heavy forging.

(TO BE CONTINUED.)

An Indian Cast-Iron Tie.

THE accompanying illustrations, from *Indian Engineering*, show a cast-iron railroad tie, designed by G. E. Moore, Deputy Consulting Engineer to the Indian Government. Mr. Moore says that experience has shown that steel ties are not suited for India, especially for the damp climate of Bengal, where they rapidly corrode on the seat under the rail, and are then useless even for scrap. Cast-iron ties have shown much greater endurance, but the drawback in using those heretofore designed has been the number of parts and the high first cost. The cast-iron pot-tie which has been used on some Indian lines is bad, as it does not give an equal bearing on the ballast, and it is also a very inconvenient form to load and ship.

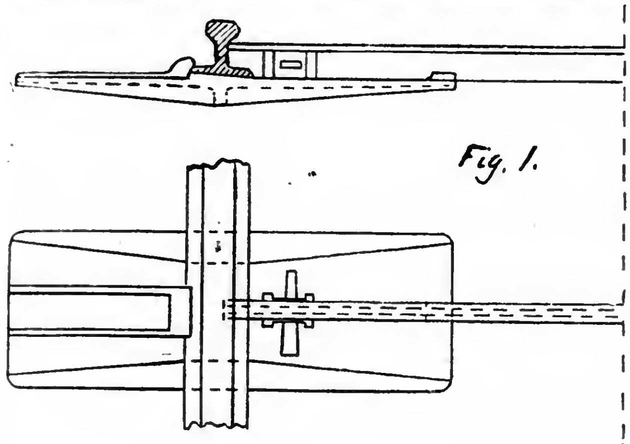


Fig. 1.

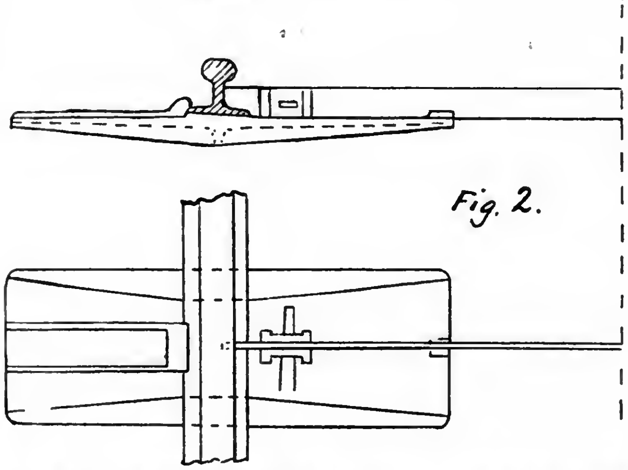


Fig. 2.

The illustrations, figs. 1 and 2, both show a form of tie designed for use with a rail section similar to that ordinarily used in this country, the only difference being in the tie-bar connecting the two sleepers, which in fig. 1 is a T-iron bar and in fig. 2 a plain bar. Each figure shows only one casting and one-half the tie-bar, the other end of the tie being exactly similar to that shown.

The operation of laying the ties is very simple, the cast-iron plates being inserted under the rail, the tie-bar placed in its seat, and the keys driven home. The gauge depends, not, as in other cast-iron ties, on the accuracy of the casting, but upon the length of the tie-bar.

The advantages claimed by Mr. Moore for his design are that there are few parts; that the cast plates are cheap and easily made, one pattern only being required; that the tie will last long, being of a simple and strong form; that the tie-bar being above the plate and not buried under the ballast, it will not rust fast in the socket; that each tie-bar is in fact a track-gauge, thus securing the accurate position of the rails; that the rail resting directly on the plate, the track will be steadier and easier to maintain, and that when renewals are required the old ties can be taken out and new ties put in easily and quickly.

The Vague Cry for Technical Education.

(Lord Armstrong, in the *Nineteenth Century*.)

THERE is at the present time a great outcry for technical education, although few people have any distinct idea of what they mean when they use that term, or any definite opinion either as to the class of persons who will be chiefly benefited by it, or as to the time of life at which it ought to be acquired. Additional zest has been given to this subject by the meeting lately held at the Mansion House respecting the scheme for establishing polytechnic institutes in London, and the present is therefore a fitting time for bringing forward ideas which have long been incubating in my mind, and which, I believe, are in accord with those of many employers of labor who, like myself, are engaged in manufacturing pursuits in which technical requirements afford most scope for application.

I have no adverse criticism to make on the speeches delivered at the Mansion House meeting, except that I think them rather vague and indefinite, as speeches on technical education generally are. Very admirable sentiments were expressed by Lord Salisbury and others on the objects sought to be attained, but there seemed to be considerable discordance of view on the part of the speakers as to what those objects should be. Lord Salisbury cautiously adopted the term secondary education instead of technical education, meaning by the former term the education which is to follow school education, and thereby using a more comprehensive phrase and avoiding the troublesome but not unnecessary task of framing a correct definition. He also spoke of this secondary education as a carrying on of primary education, but he ignored the question whether the existing system of primary education is worthy of being

followed up on its present lines, or whether it requires to be altered to make it more in harmony with the proposed secondary stage. Lord Salisbury most truly said that the first necessity of man is to live, that his first duty is to work, and that the first object of education is to fit him for work; but much as I applaud these words I doubt whether I am in unison with his lordship as to the kind of education which would best fulfill the object he thus enunciates.

In expressing my own views on popular education I must address myself, in the first place, to the present system of primary or elementary education, which is now very generally considered to be ill-adapted as a preparation for the business of life. That system has, in my opinion, the radical defect of aiming at instruction in knowledge rather than the training of the faculties. A man's success in life depends incomparably more upon his capacities for useful action than upon his acquirements in knowledge, and the education of the young should therefore be directed to the development of faculties and valuable qualities rather than to the acquisition of knowledge, which may be deferred to more mature age. Not only should the mind be trained in habits of thought and in quickness and accuracy of perception, but the hand, the eye, and the ear should all participate in training exercises calculated to make these organs more available as instruments of the mind. Nor should the development of the physique be neglected, for, with the great majority of both men and women, personal vigor and activity are the foremost factors in making a living. Except in teaching the art of writing—which, as a rule, is very imperfectly done in elementary schools—no attempt is at present made to educate the hand. The addition of drawing would be a step in the right direction, and would afford a useful accomplishment, but would not supply all that is needed for giving dexterity to the hand. Appropriate exercises ought to be devised for cultivating its mobility, precision, and delicacy of touch; and if, in so doing, the ability to use simple tools were acquired, it would be advantageous in any line of life that might be ultimately adopted. Every man and woman would be the better for pre-acquired manual dexterity, but to attempt to teach children special trades and processes of manufacture would, I conceive, be a mistake. It would involve great expense, would be a misapplication of time, and would only forestall the more effectual teaching which at a more suitable age may be attained by actual practice in factories and workshops. As to the thinking faculties, they are to a certain extent at present exercised in learning arithmetic, but it would be better if this were done more by reasoning than by rule. The late Mr. Bidder, who as a youth was called the calculating boy, used to say that he never learned a rule of arithmetic in his life, but taught himself to comprehend the relations of numbers to each other and the result of their combinations by handling groups of peas in such a manner as to visualize a system of arithmetic which his mind could grasp with perfect distinctness. It is by methods such as this rather than by books and rules that the minds of children should be led on to the forming of clear ideas and to the exercise of reasoning power. A rule may be committed to memory for convenience of use, but the first object should be to make the learners understand, as far as possible, the reasons upon which the rule is founded. But the present system of elementary education does little else than burden the memory with facts, rules, and information, which for the most part are of little use for developing the intellect, or preparing it for the ordinary vocations of life. Such instruction excites little interest in the minds of the pupils, and in the vast majority of cases is speedily forgotten. Even in the case of the few youthful minds that appreciate knowledge as thus learned and display superiority in acquiring it, the effects are by no means invariably beneficial, seeing that such superiority tends to create a fastidiousness which makes manual labor distasteful. Successful scholars, if boys, generally think themselves too good for mechanical work, and aspire to be clerks or teachers, and, if girls, they shun domestic service, and aim at employment as shopwomen, telegraph operators, and so forth. Thus the *élite* of the popular schools seldom engage in manual labor, and when they do, their school acquirements are not conducive either to efficiency or contentment.

The teaching of reading, writing, drawing, and arithmetic are all distinct from instruction in knowledge. They are means to an end, and are necessary both to the attainment of knowledge and to its utilization. I do not mean to say that the inculcation of knowledge should be wholly excluded from popular schools, but I think it should be limited to knowledge of a very fundamental nature, such as may serve as a basis to build upon in adult life. Juvenile lectures on experimental science followed by easy examinations would also serve a useful purpose by exciting the interest of the pupils and leading to habits of observation and reflection favorable to future acquirements.

Professor Huxley has well said that our present system of elementary education is much too bookish; and, in my opinion, this bookish teaching might be cut down to very small dimensions, so as to admit of the introduction of an effective system of mental and physical training, without adding to the present cost of popular education. If I am asked to specify the particular methods by which such training should be effected, I reply that I am not sufficiently an expert to be able to do so, but it is not difficult to form general ideas on the subject. All organs and all faculties are developed by exercise, and the application of appropriate exercises constitutes training. Just as athletics are practised for developing the muscles, so may analogous exercises be used for developing all the physical organs as well as the mental faculties. If a juvenile pickpocket can be trained to use his hands with exquisite adroitness in the practice of his nefarious occupation, why should not the hand of a schoolboy acquire by proper training similar mobility and delicacy of touch to be used for honest purposes? Houdin, the celebrated conjurer, states in his amusing memoirs that he and his son practised the receptive power of their eyes by walking quickly past shop-windows, and then recounting all the objects which in a moment of time had been presented to their view. The faculty of perceiving at a glance all the details of a complicated situation, or condition of things, is most valuable in enabling prompt action to be taken not only by conjurers, but by persons in every vocation of life, and especially by those in positions of command. I may also observe that the cultivation of "eye-memory," such as would be acquired by an exercise of this kind, would greatly facilitate the acquirements of correctness in spelling, which is a source of great difficulty with many intellects not otherwise defective. I mention these examples of training not as definite proposals for adoption, but as illustrations of what can be done by appropriate exercises.

I need hardly say that the ear as well as the eye can have its capabilities exalted by the operation of training. The power of minute discrimination can be given to both, and the one can be awakened to a sense of symmetry and the other to that of harmony where those perceptions are naturally dormant or defective. In fact, all organic developments, including the functions of the brain, turns upon exercise. In cleverness of hand and eye, and in promptitude of action, children at present learn more from their games than from their teachers, and I am inclined to think that training associated with amusement might be so systematized as to produce excellent results, both in mental and bodily development, as well as in the promotion of health and vigor; but in relation to these I may observe that a sufficiency of food and clothing is especially necessary. Indeed, the want of it in the children of poverty-stricken parents is already a serious difficulty in popular education.

It is related by Sir Frederick Pollock, in his interesting reminiscences, that when he was at the University of Cambridge one of the subjects submitted for discussion at a debating club was the question, "What is the use of useful knowledge?" We are not informed what was the result of the debate, nor is it important that we should be so; but the question appears to me to present in a quaint form a theme of a very debatable nature. I think it must be conceded that where a man fails to get on in the world it is not from want of knowledge so much as from want of natural capacity, and of zeal, energy, and perseverance. If he possess natural capacity, combined with these qualities, he will surmount all difficulties in attaining it. If there be capable men striving after knowledge necessary to their advancement and unable to obtain it, they have not come

within my observation, and as to the incapables, it would be no advantage to them if they had it. Many people imagine that genius is kept down from want of knowledge, and that in many cases it is thus lost to the world. This I entirely dispute. Genius is irrepressible, and revels in overcoming difficulties. Except in what are called the learned professions, few men who have risen to distinction have owed their success to book knowledge thrust upon them in early life. Among engineers I may instance James Watt, George Stephenson, Smeaton, Brinley, and Telford, as men who have made a great mark in the world, some of them a transcendent mark, and yet none of them were loaded with information at school, but were left to educate themselves in after life, with scant facilities, in such knowledge as was necessary to the exercise of their talents and the attainment of their ends. Their receptive faculties might have been quickened by early cramming; but their originality would probably have been impaired, and their natural talents, instead of being concentrated upon the line of thought for which they were best fitted, would have lost effect by diffusion in unprofitable channels. The well-known dictum that if the Romans had had to learn Latin they never would have conquered the world, is suggestive of what our loss might have been if these self-made engineers had frittered away their energies upon inappropriate studies forced upon them at school. What I have said of engineers may be said with equal truth of men who have attained success and reputation in the various phases of mercantile life, and also in the naval and military professions. Take Wellington and Marlborough among generals, and Nelson and Blake among naval commanders. Surely none of these would have directed the armies and navies of England with more effect if book knowledge had been crammed into them at school, and it is highly probable that their services would have been lost to the nation if success in competitive examinations, such as are now in vogue, had been made a condition of their entering the Army or the Navy.

If I were to ask the question, For what class of persons is technical education more especially required? I suppose most people would say, the working classes; but I think a little consideration will show that this answer would not be correct. It must, I conceive, at once be admitted that in the numerous class of laborers figuratively styled "hewers of wood and drawers of water" no man would be rendered more efficient by the possession of any kind of technical knowledge, although the value of his labor would undoubtedly be enhanced by his having been, as a boy, trained in the exercise of his hands and limbs. Making one step in advance of the wholly unskilled laborer, let us take, for example, the case of a "hewer of wood" in the more special sense of a woodman skilled in the use of his axe. To do his work properly would require skill, though of a humble kind, and some degree of intelligence, as well as strength of arm; but it cannot be said that technical education, distinct from that which he acquires for himself by his own practice and experience, would add to his skill and efficiency, whether he be an unlettered laborer working for wages, or a distinguished statesman practising as an amateur. Ascending a step higher in the scale of labor, we may take the case of artificers, such as joiners, carpenters, fitters, and all others who work in wood and iron for constructive purposes. Here again we find manual skill, intelligently used, the chief criterion of the value of their labor. These men in general work under direction, and so long as they do so, it is their manual skill, and not their knowledge, that comes into play. It is, therefore, not easy to see how knowledge distinct from manual skill can add to the value of their labor. As to those whose office it is to direct such labor, they are men chosen for their superior intelligence as well as skill to act as foremen, and whose duty requires them to work more with their brain than with their hands. They, in fact, are persons who emerge from the class of manual workers, and it is here where the value of technical knowledge first comes in. But even in their case all the information they required can be found in a condensed and tabulated form in hand-books applicable to all kinds of constructive art. Such technical information is in this form available to every man who can read and do arithmetic, however ignorant he may be of the scientific methods by which such tabulated results have been arrived at. No doubt these hand-books will fulfill their purpose more completely if those who consult them can work simple algebraic formulas or have a slight acquaintance with geometry; but these limited accomplishments can easily be acquired by private study, and are quite within the reach of self-education. In fact, experience shows that it is men of this stamp who, on leaving school, have voluntarily availed themselves of the facilities offered for self-education in order to qualify themselves for positions of responsibility and superintendence. The next class we have to consider is that of managers and designers, who require technical education in a higher degree; but even here it is only in rare instances that high attainments in science are essential to practical results. It is only in pursuit of research and discovery that highly advanced scientific knowledge is required, and not even then in all branches of science.

Upon the whole, I am of opinion that the number of persons who would be benefited in business by scientific education of a technical nature, and who have the zeal, capacity, and perseverance necessary to its attainment, constitutes a very small proportion of the population, and it remains to be considered whether the existing facilities for the voluntary acquisition of technical knowledge are sufficient, or to what extent they require to be supplemented. These facilities, as they are found in large towns, consist, in the first place, of evening classes conducted under Government auspices for the teaching of practical and applied science. If knowledge for clerkships be wanted, such as book-keeping and short-hand writing, those subjects might be taught at a small expense in a similar manner, and doubtless would be so if a desire for it were manifested. There are also various associations of a general scientific character, and others specially applicable to particular lines of business, at which institutions papers are read or lectures given on appropriate subjects, and other facilities offered for self-education. These associations might be multiplied to any extent and be made applicable to every variety of business, and I believe their multiplication does actually keep pace with the demand for them. The people have also the advantage of university extension lectures, and they have access to abundance of libraries either absolutely free or belonging to mechanics' institutes or scientific societies to which any one can be admitted on payment of a very small annual subscription. There is also the universal advantage of cheap scientific literature, including books of reference of a technical nature applicable to almost every kind of employment on which science can be brought to bear. The chief want appears to me to be that of public laboratories, to which qualified students could be admitted for the practice of experimental science. To these laboratories class-rooms should be attached for evening teaching. As to colleges of physical science, they are apt, I think, to be too scholastic for popular requirements, though valuable for the cultivation of theoretical science of a more abstract nature, and also for the education of those who have to become teachers of science. These colleges could be made to embrace more practical instruction than they do, but such instruction is attainable at a smaller cost by the means I have described. When colleges can be established by public subscription or private munificence, they are worthy of approval and commendation; but where the State or local governing bodies have to furnish money for education in relation to national industry, they must look to attaining the required results at the least possible expense, and I am inclined to look upon colleges as luxuries in education rather than necessaries.

But it is only in large towns that the facilities I have mentioned are to be found, and it would certainly be desirable that small towns and rural districts should be placed in a position to afford practical scientific instruction to all capable persons who earnestly seek to attain it. In rural districts the chief occupation is agriculture, the practice of which would be benefited by technical instruction which is not at present provided. Great ignorance prevails in the practice of this important industry, but there does not appear to be much desire for enlightenment among the farming population, for in the few cases where night schools have been established for useful in-

THE INMAN LINE STEAMER, "CITY OF NEW YORK."

BUILT BY J. & G. THOMSON, GLASGOW, SCOTLAND.

struction relative to farming, the attendance has been very unsatisfactory.

As to the question whether our commerce is to be saved from the effects of foreign competition by a wide diffusion of technical knowledge, I have no faith in any such safeguard. Cheapness of production and superiority of quality will decide the victory in the race of competition, and if by early training we develop the mental and bodily faculties of our people, we shall improve our chance of maintaining a foremost place; but not, I think, by any forced or indiscriminate system of imparting knowledge. I do not undervalue technical knowledge voluntarily acquired as a means to an end, but it is the brain-workers and not the hand-workers who will seek to attain it and benefit by it. Compulsory education is neither justifiable nor practicable except in childhood, and without compulsion I am satisfied that it is only individuals of superior intellect and fitness for business that would perseveringly avail themselves of new educational facilities. Such new facilities should await the demand for them, and be supplied gradually and tentatively, for it would be folly to rush into new and costly projects without any certainty of their resulting in adequate benefit. I most heartily concur in Professor Huxley's commendation of the great services rendered by the Science and Art Department in the promotion of evening classes for the teaching of art and practical science; and if Government intervention be needed in other branches of technical knowledge, I think it would be wise merely to expand in the same economical and unpretentious line of action.

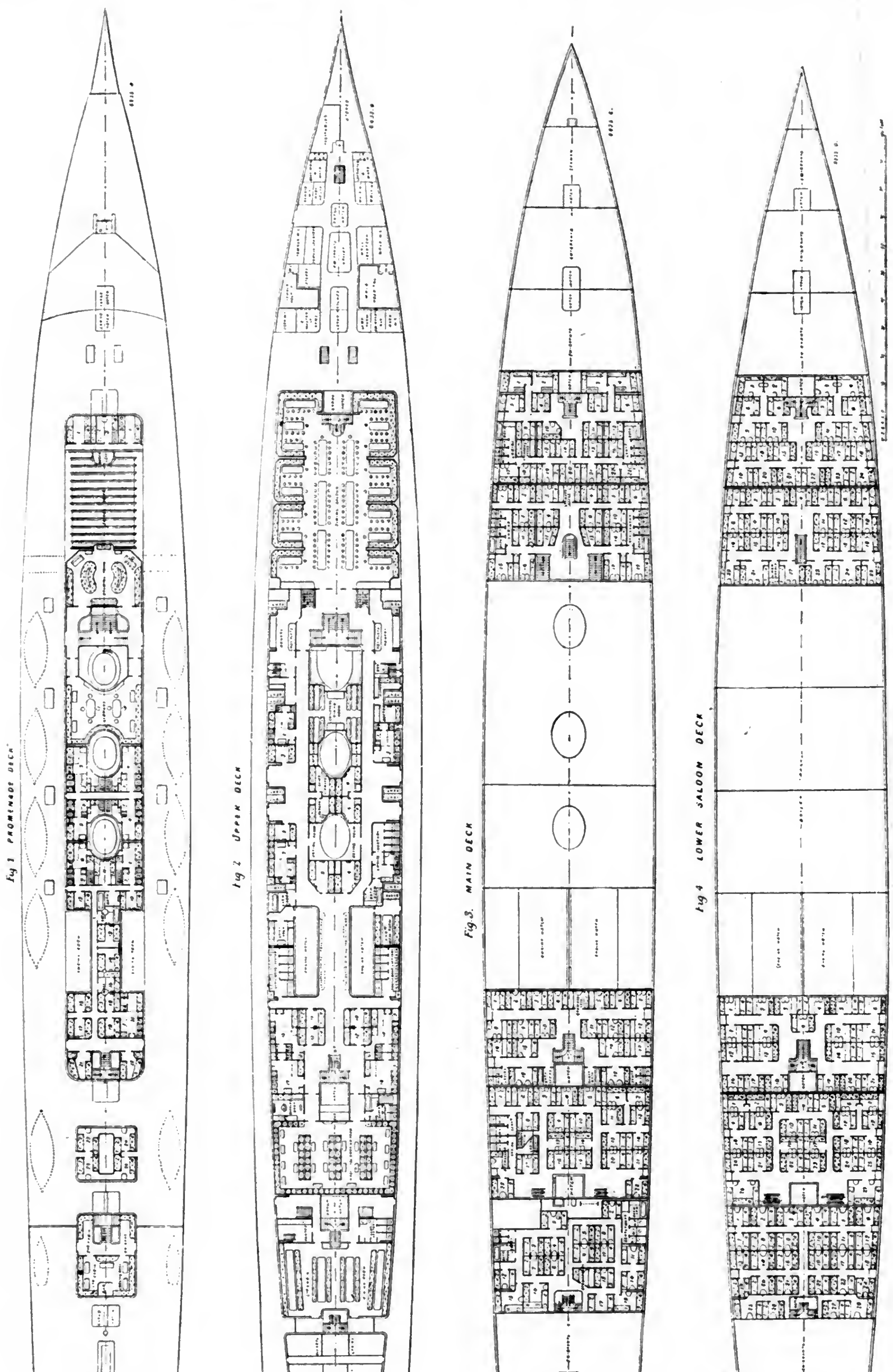
In the preceding remarks on popular education it must be understood that I am viewing the subject in a purely utilitarian aspect. My topic is technical education, and I leave untouched all questions relating to instruction of a religious and moral nature. Happily those subjects are now treated in a much more conciliatory spirit than formerly, and I hope that any remaining impediments to popular education of an elevating kind may eventually disappear.

THE STEAMSHIP "CITY OF NEW YORK."

THE new Inman Line steamer *City of New York*—the largest vessel ever built for commercial purposes except the *Great Eastern*—completed her first voyage across the Atlantic on August 10. This voyage, with entirely new machinery, was not a test one, and the ship is expected to be one of the fastest in the Transatlantic service. The accompanying illustrations, showing the deck plans and the engine, are from the London *Engineering*; the general view of the vessel is taken from the London *Engineer*, together with the description which follows:

Nothing in history is more remarkable than the development of the Atlantic passenger trade. For a considerable period after the construction of the *Great Western*, progress was comparatively slow. The *Persia*, launched in 1851, represented finality for a long period, and it may be safely said that no important advance on the *Persia* could have been possible but for the advent of the surface condenser and higher pressures. For even though the screw had taken the place of the paddle, the gain would have been moderate so long as low pressures were retained. The compound engine rendered another great stride possible, and the *Alaska* began to show shipowners that it might be practicable to place New York within little more than a week of Liverpool. Later on came the *Oregon*, the *Etruria*, and other ships whose names are famous. But enormous as is the advance represented by the *Etruria* as compared with the *Persia*, it has not given contentment. The *Etruria* has compound engines. The triple-expansion system promised still higher speeds, and the *City of New York* is the very latest development, representing the maximum effort for the time being of engineers and shipbuilders. The startling feature about the practice of Atlantic steam navigation is that it is perfectly well understood that the *City of New York* will be probably obsolete in five years. Her owners even now contemplate building something better; and Messrs. Harland & Woolf have in hand for the White Star Line a ship which it is hoped will be more powerful, more rapid, and more magnificent. We hold our breath when such statements are made. But it is impossible to argue that they are untrue; we cannot set a limit and assert that it shall not be passed. But let us pause here for a moment and consider what the desire for speed means. No official statement of the results obtained by the *City of New York* has been made public; all that is known is that about 19,000 indicated H.P. gave a speed of over 20 knots, with a displacement of about 12,000 tons. Now the power required to propel a ship at different speeds varies in a more rapid ratio than the cubes of the speeds. The *City of New York* has twin screws. Each set of engines indicates 9,500 H.P. A very simple calculation will show that one set would suffice to drive her at a speed of 17 knots, which would take her across the Atlantic in less than eight days. A speed of 20 knots would take her across in a little over six days. To save about 36 hours on the passage, the engine power, and with it of course the boiler power and the coal consumption, are doubled; and great as the sacrifice appears to be, it is not regarded as too much, and beyond doubt the coming Atlantic steamer will be nothing more than a gigantic torpedo boat. She will be filled below with machinery, while above she will be a palatial hotel. Even coal she will not carry in excess—just enough for a single voyage. For although American coal were not used on her return voyage, it would not pay to send coal in a passenger steamer merely to bring her back again. Coal will be transferred across the Atlantic in cargo boats for the use of the ocean racers.

Leaving the question of the future to take care of itself, let us deal with the present, and consider what manner of ship the *City of New York* is. Our readers will see from the illustration that her three elliptical funnels give her a general resemblance to the *City of Rome*; her shape is, however, more elegant and yacht-like. The bows of the *City of New York* are peculiarly graceful, and the way in which she behaved in half a gale dead in her teeth coming round the Irish coast imparted convincing proof that, sharp as her bows are, she will be a dry ship. Her fittings and internal arrangements are in many respects unlike those of other Atlantic steamers. It has long been the practice in large vessels to leave a wide open space above the main saloon, and to surround this with a balcony or gallery known as the music-room. There is nothing of the kind in the *City of New York*. The main saloon has, indeed, an opening, but this is covered by a semicircular stained glass roof 33 ft. long and 25 ft. span placed inside an external roof of steel plate with stout glass in it, which protects the inner roof, but is itself not seen from below. At one end of the arch is a species of balcony on which stands an organ; at the other end is a somewhat similar balcony supporting a stained-glass window, the sashes of which open on hinges. This window belongs to the drawing-room, a beautiful apartment covering nearly one-half the length of the main saloon on the deck above it. All the decorations are in white and gold, a species of elastic plaster being freely employed with excellent effect. The main saloon is partly cut up by four semi-bulkheads forming recesses, each of which holds two tables for ten persons each. The woodwork is ash, sycamore, and other decorative timbers. Nothing has been overdone, and the effect throughout is, as an æsthete would say, "restful." As concerns the state-room accommodation, that has to a large extent been assimilated to hotel practice. It will be best understood if we give here particulars supplied by her builders. The promenade deck, which is the topmost of all, extends from stem to stern. There are various erections in the center, including several of the principal rooms; but these do not interfere with the promenade itself, as there is on either side of these houses a clear space of 18 ft. The lifeboats are carried 8 ft. above the deck, and do not form any obstruction. In order to carry out the hotel idea, the *City of New York* has been arranged with private apartments. These are situated on four decks, and within 155 ft. of the center of the ship. The largest of these private apartments are fourteen suites of rooms equally divided between the promenade and upper deck.



THE INMAN LINE STEAMER, "CITY OF NEW YORK."—DECK PLANS.

BUILT BY J. & G. THOMSON, GLASGOW, SCOTLAND.

Arrangements are made for having food served in these rooms, and passengers may invite fellow-travelers to their own cabins and entertain them there. Adjoining the parlors are private bath-rooms, and there are also 25 day sitting-rooms for first-class passengers. A novel arrangement consists in the fact that if the rooms are required for sleeping accommodation beds can easily be improvised. State rooms are provided besides on the main and lower decks in the center of the ship for 479 first-class passengers. These rooms are admirably decorated, and the ventilation is complete. The first-class smoking-room is situated on the upper deck at the after-end. It is 45 ft. long and 27 ft. broad, and will seat 130 gentlemen. In this commodious room, which is beautifully fitted up, there is a large bar from which passengers can be supplied with all kinds of refreshments. The second-class dining-saloon is situated aft on the upper deck, and is 27 ft. long and 40 ft. wide, capable of accommodating 150. There are also 96 state-rooms for 390 second-class passengers situated in the after-end of the main and lower saloon decks. The emigrants have fine, airy rooms provided for them at the two extreme ends of the lower main decks. The sleeping berths are in the middle line of the ship, and not, as is usual, built up on the side of the hull, and here the ventilation is also of the best, with Broadfoot's special deck and side ventilators. The *City of New York* is the largest passenger-carrying vessel now afloat. She is 2,500 tons larger than the *Servia*, 2,723 tons larger than the *Etruria*, and 2,340 larger than the *City of Rome*. She is 565 ft. long over all, 63¼ ft. broad, 42 ft. deep—moulded—and 10,500 gross tons, with accommodation for fully 2,000 passengers. She is fitted with five decks, and the space between four of them is 8 ft., but between the upper and main decks is 9 ft. 4 in., while the depth of the hold is 39½ ft. To give an adequate idea of the height of the *City of New York* it is as well to mention that from the keel to the captain's bridge is 76 ft. The hull is all double butt-strapped for strength. The effect is not pleasing, and it is open to doubt whether or not the straps augment her resistance. Below the water-line it ought to be possible to bring her to a smooth surface with cement.

In order to avert rolling, the ship has been fitted with a steadying tank. This is a chamber containing water, placed athwartships, and is intended to arrest or check rolling by the transfer of the water from one side of the ship to the other, at such velocities as will modify her own periodic or rolling time. Parallel tanks of the kind have been used in war ships. Mr. Biles has carried out a most extended series of model experiments, with the result that while he ascertained that a parallel-sided tank would do very little good in the case of the *City of New York*, he also found a method of constructing the tank which would give perfectly satisfactory results. This he effects by delaying the time of transfer of the water from one side of the ship to the other, which result is brought out by making the tank of a saddle form instead of with parallel sides.

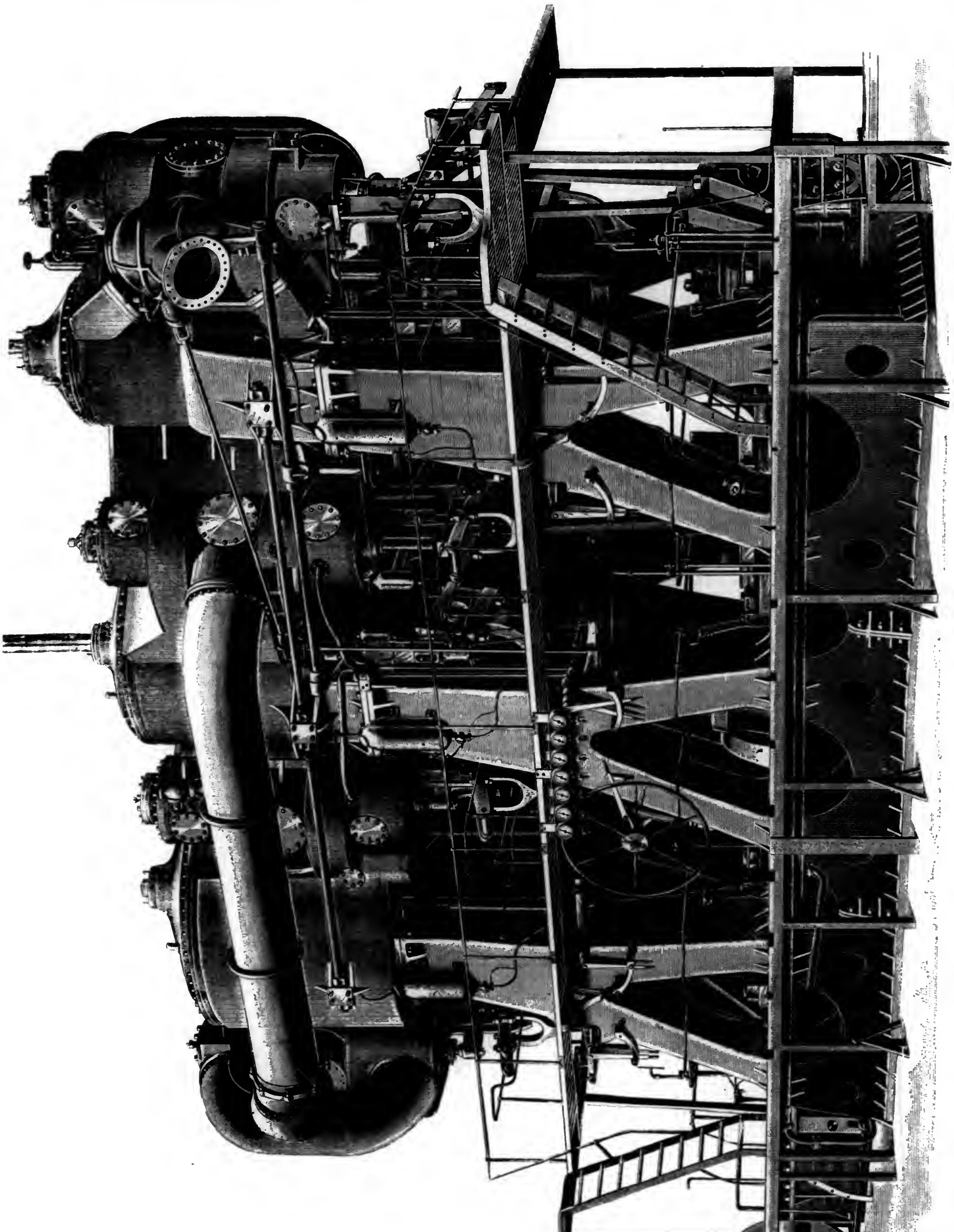
Enormous as the ship is, she is steered with a tiller like a yacht. Strictly speaking, four tillers are provided, one on the upper or monkey-bridge; one in the so-called wheel-house immediately below; one on the poop, and another far below in the after peak of the ship under the water-line, where also is the hand-steering gear with four wheels, for manual power. The steering gear is Brown's patent, made by Messrs. Brown Brothers, of Rosebank Works, Edinburgh. In each of the two main engine-rooms is placed one of Brown's hydraulic engines, which supplies a system of mains, traversing the ship fore-and-aft, with water at a pressure of about 1,000 lbs. on the square inch. The engines are vertical, compound rotative, and pump the water into a steam accumulator; the steam at 150 lbs. on the square inch driving down a piston, the thick rod of which plays the part of the ram of an ordinary dead weight accumulator. The pressure water is employed for working the hatch derricks, weighing the anchors, etc., and also for steering. The *City of New York* has an enormous rudder, partially balanced, and of peculiar construction. It will be remembered that the ship is on the Admiralty auxiliary list, and in order to render her rudder safe from hostile fire it is wholly submerged. There is no rudder-head to be seen from the outside; inside it terminates in the after peak below water-level. It is fitted with a tremendous cross-head or tiller, which is operated by two hydraulic rams. Room for these could not be found sufficiently far aft, so they are linked to the cross-head or tiller, as it may be called, by a round steel bar 12 in. in diameter and about 12 ft. long.

The rams are about 18 in. in diameter, and have, it will be seen, tremendous power over the rudder. In order to provide against the effect of shocks caused by the impact of the waves, there is a loaded relief valve on each of the hydraulic presses. The water is admitted to either press by valves which are situated near the bow of the ship. These valves are plain slides in a small box, and they are controlled by a tiller about as large as would be used in a 5-ton yacht. The tiller actuates one end of a short lever. The fulcrum end of this lever is controlled by an arm on the vertical spindle of a quadrant which lies under the deck. Two steel wire ropes, each with a breaking strength of seven tons, and stressed to about one-half a ton, run from the rudder-head to the quadrant. The effect is precisely that of the hunting gear in a steam steering gear. As soon as the steersman puts the tiller he holds to port or starboard the appropriate valve just under his feet is opened. The rudder then moves, and through the medium of the wire rope it closes the valve, so that the rudder is held in its new position. Another movement of the tiller opens the valve. The corresponding motion of the rudder shuts it again, and so on. Thus the great ship can be steered by a boy. The practice was so novel to the men that it was difficult at first to get a straight course kept by those who had been accustomed to a wheel; and we are told that the best steersman on board was a quartermaster well up in yacht sailing.

The engines which supply the hydraulic power are extremely ingenious. One very beautiful device is that by which they are automatically rendered non-compound for half a stroke, in order that they may start with certainty after standing. They run quite freely and steadily at any speed, and for any portion of a stroke required to keep the accumulator up.

A complete electrical plant has been fitted on board by Messrs. Brown Brothers & King, the power being supplied by five engines and dynamos placed on a platform between the two main engines and above the level of the tops of the cylinders. These engines and dynamos supply current not only for light, but to four large horizontal fans on the hurricane-deck driven direct by motors. These fans and motors are located in the tops of ventilating shafts extending down into the depths of the ship, from which they draw air. This is, so far as we know, the first time that electricity has been used for ventilating purposes in a ship.

It is now time to speak of the machinery by which the ship is propelled. This consists of the two largest sets of triple-expansion engines afloat. They are of the usual inverted vertical type. The cylinders are 45 in., 74 in., and 113 in. diameter, and 5 ft. stroke. The boiler pressure is 150 lbs. The screws are 22 ft. in diameter and 28 ft. pitch. They revolve outboard, and there is no opening in the dead-wood between them. If they worked without slip they would make 218 revolutions to the mile, and at 80 revolutions, which may be taken as the standard speed, the ship would steam at 22 knots. With a slip of about 9 per cent., therefore, the speed of the ship will be 20 knots. The engines stand side by side, with a longitudinal bulkhead between them. They are in every respect duplicates. A door is provided in the bulkhead opposite the intermediate cranks, and the starting platforms are opposite the doorway. The reversing gear is Brown's patent hydraulic. The engines are quite easily started, stopped, or reversed by one engineer on each platform. The engines are wholly of steel and gun-metal, save the cylinders. The great A-frames are splendid castings, each weighing 6 tons—that is, 12 tons for each cylinder. The valves are all pistons—four being fitted to the low-pressure cylinder, two to the intermediate, and one to the high-pressure cylinder. The eccentric hoops are cast steel, lined with white metal, as are all the bearings throughout. The valves are disposed in the "corners," so to speak, and the valve-stems are united in pairs by cross-heads. They work



TRIPLE EXPANSION ENGINES, STEAMER "CITY OF NEW YORK."

BUILT BY J. & G. THOMSON, GLASGOW, SCOTLAND.

so smoothly and are so perfectly balanced that the valve gear, which is of the ordinary Stephenson link type, has really very little to do. The surface condensers are horizontal cylinders lying rather high up in the wings. The air-pumps are worked by back levers in the usual way.

There are no feed-pumps on the main engine, the boilers being supplied by five vertical Worthington donkey-pumps in each engine-room, standing against the forward bulkhead. Two of these pumps will feed the boilers, but the others are for reserve, or for the countless pumping jobs wanted in a big ship. The engines actually employed at any time in feeding the boilers are controlled by an automatic arrangement, a float in the hot-well rising or falling with the level of the water in the well, and opening or shutting the throttle valve, an arrangement which is, so far as we are aware, quite new in marine work, and found to answer admirably, the donkey remaining steadily at work instead of tearing away for a few minutes emptying the hot-well, and then having to stand until the well fills again. It would be difficult, if not impossible, to find more admirable examples of the highest type of mechanical engineering than is supplied by the splendid main engines. They have been constructed throughout from the designs of Mr. J. Parker, who also designed the very different, but equally admirable engines of the war-ship *Aurora*. Mr. Parker has brought to bear on his task a lifelong experience. He was for some years second engineer of the great paddle steamer *Persia*, which had side-lever engines, the cylinders 100 in. in diameter, with a stroke of 10 ft. Mr. Parker's familiarity with all the difficulties and trials which beset the sea-going engineer has stood him in good stead ; and the engines of the *City of New York* will maintain the fame of Scotch engineers in the New and the Old World. Nothing finer can be imagined than the working of these gigantic engines, with a piston speed of 800 ft. per minute—certainly the greatest velocity ever attained by pistons 9 ft. 5 in. in diameter. During the whole run round Ireland, on the trial trip of the vessel, lasting nearly 46 hours, not a drop of water was needed on a bearing, nor were there the least symptoms of heating.

An important experiment to which we have not yet referred is being carried out in the *City of New York*. Although she is a much larger vessel than the *Umbria* and the *Etruria*, and is intended to be faster than either, she has less boiler power. The *Etruria* has 72 furnaces. The *City of New York* has only 54, disposed in nine double-ended boilers, and containing 1,250 square feet of grate surface. The apparent deficiency is met first by the use of triple-expansion engines, which should be about 20 per cent. more economical than the three-cylinder compound engines of the *Etruria* ; and secondly by the use of forced draft. The nine boilers are placed in three stokeholes. The boilers are fired fore-and-aft, and no direct communication between the boiler compartments exists. Access can be had to each only by ladders and hydraulic hoists. There is, we may add, a similar hoist in each engine-room. Instead of the usual forest of cowl ventilators, there are erected at each side of the upper deck six large rectangular structures of heavy plate iron fitted with shield lids, which can be raised or lowered by screw gear. When dropped down, a sufficient space exists for the entry of air. In fine weather they are raised to an inclined position and deflect air down the trunks. These trunks reach down to the fire-rooms, and each is provided at the bottom with a fan about 5 ft. 6 in. in diameter, driven by a separate engine at about 500 revolutions per minute. These fans deliver one at each side of the ship into the six stokeholes, in which they can maintain a plenum of about ⅝ in. water pressure. So far the result of the experiment is all that can be desired. During her trial trip the pressure of 150 lbs. was maintained in the boilers. The engines made, one 82 and the other 83 revolutions per minute, and a speed of over 20 knots was attained with about 18,500 H.P. No precise data as to power or speed has, however, been officially given. There is every reason to believe that when the engine and fire-room hands have thoroughly settled down to their work, 20,000 H.P., or a little more, will be obtained.

The *City of New York* has now made her first trip across the Atlantic, but no statement of the working of the engines has been made public.

UNITED STATES NAVAL PROGRESS.

NEXT to the *Charleston*, which was launched at San Francisco in July, the most advanced of the new cruisers is the *Baltimore*, which was to be launched from Cramp's yard on the Delaware about the close of August. The *Baltimore* is an unarmored cruiser like the *Charleston*, but is somewhat larger than that vessel, having a displacement of 4,400 tons. She is 315 ft. long, 48½ ft. beam, and will have a maximum draft of 21 ft. The contract price for the hull and engines is $1,325,000, and she was to have been completed in June, but the time has been extended, chiefly owing to delays in inspection and delivery of the steel of which her hull is constructed. The *Baltimore* has a double bottom, and is divided into many compartments by water-tight bulkheads. As stated above, she is an unarmored vessel, but has a protective or armored deck varying from 2½ to 4 in. in thickness, while the arangement of the bulkheads and coal-bunkers is such as to protect the machinery and vital parts of the vessel as far as possible. She will have no sail power for ordinary use, but will be provided with storm-sails carried on the two military masts, both of which are fitted with fighting tops.

The main battery of the *Baltimore* will consist of four 8-in. and six 6-in. breech-loading rifled guns, while she will have as a secondary battery 11 Hotchkiss and Gatling guns, and will also carry a torpedo equipment.

The design of the *Baltimore* was originally from Mr. White, who was, at the time the plans were furnished, in the employment of the famous English firm of Armstrong & Company, and who is now Constructor in the British Navy. The plans were somewhat modified in our Navy Department, but are substantially those made by Mr. White.

Like the other cruisers, the *Baltimore* has two screws with triple-expansion engines ; these engines will work up to 10,500 H.P. with forced draft, and the contract speed will be 19 knots an hour, which is greater than that of any of the vessels which have preceded her. She will carry coal enough to give her a very extended cruising range at a moderate speed, and is expected to be an exceedingly useful vessel.

The preparations for building the armored cruiser *Maine* at the New York Navy Yard are well advanced, and work will be begun as soon as a good supply of material is delivered. The *Maine* is the heaviest of the vessels yet authorized for the new Navy, and differs from the earlier cruisers, like the *Atlanta*, the *Boston*, the *Charleston*, and the *Baltimore*, in carrying heavy armor. She is of what is known as the belted cruiser type, with armored turrets, the heavy guns being carried in turrets raised above the main deck, while an armored belt protects the vital parts of the ship. The design is very similar to that of the cruiser *Riachuelo*, built recently for the Brazilian Government, the performance of which has been very good.

The general dimensions of this ship are : Length between perpendiculars, 310 ft. ; extreme breadth, 57 ft. ; mean draft, 21½ ft. ; displacement, 6,650 tons. The armor belt will be 11 in. thick, extending 180 ft. amidships, from 3 ft. above to 4 ft. below the water line. The steel armor-plates are to be carried on wood backing 8 in. thick, and at the forward end of the belt there is a bulkhead 6 in. thick running entirely across the vessel.

The revolving turrets will be protected by steel armor-plates 10½ in. thick. On the raised casemate there is a conning-tower of elliptical form 10½ by 9 ft., protected by armor 10 in. thick. The ship will have a double bottom, with the usual arrangement of coal-bunkers, etc., to protect the engines as much as possible.

The *Maine* will have three masts and will be bark-rigged ; the fore and main masts are to be fitted with military tops, each carrying two small machine guns. In addition to the usual allowance of boats, including two steam launches, she will carry on deck two torpedo-boats, each 60 ft. long. The principal battery will consist of four 10-

in. steel breech-loading guns, two mounted in each of the turrets, the latter to be arranged in *echelon*, so that all four guns can be fired ahead or astern at the same time; the 6-in. guns are mounted in the raised central breastwork or casemate, having especial protection for their gunners in the form of steel shields 2 in. thick. Two of these 6 in. guns are placed forward and two aft, while the remaining two are mounted one on each side of the central structure. The secondary battery consists of four 57-mm. rapid firing guns, four 47-mm. guns of the same kind, four 47-mm. and nine 37-mm. revolving cannon and four Gatling guns. There will be also seven torpedo tubes, which can be used on occasion. The 10-in. guns will use a projectile of 500 lbs. weight with 250 lbs. powder, and are expected to have a maximum range of nine miles.

In the design of this vessel great care has been taken to provide convenient quarters for the officers and crew. She will be fitted with elaborate systems of pumping and ventilation by machinery, and is provided with several dynamos which will serve to light the vessel throughout with incandescent lights, and also to supply three powerful searchlights. The electric arrangements will be so made that in case of damage to one dynamo, connections can be at once made with another.

The *Maine* will have two screws driven by two triple-expansion engines, each placed in a separate water-tight compartment. Each of these engines has cylinders 35½, 57 and 88 in. in diameter, with a stroke of 36 in. Steam will be furnished by eight cylindrical return tubular boilers 14 ft. 8 in. diameter and 10 ft. long, each having three furnaces. Forced draft will be secured by leading air to the under side of the grate-bars and there will be four blowers, having a total capacity of 26,000 cubic feet of air per minute. With forced draft the engines are expected to develop 8,750 H.P. The total capacity of the coal-bunkers will be somewhat over 800 tons, and with a full supply the ships will be able to steam 1,900 knots at full speed, 3,200 knots at 15 knots an hour, and 8,500 at 10 knots an hour, thus giving her a large cruising range at low speed.

The cruiser *Atlanta* is to receive some repairs and slight alterations, as recommended by the officers who have been in charge of her, and will then be sent on an extended cruise.

The Naval Appropriation Bill has not yet been acted upon in Congress, so that it is uncertain whether the large cruisers proposed will be authorized this year or not. It seems probable, however, that the bill will pass in something like the form which it has received.

Blast Furnaces of the United States.

THE *American Manufacturer*, in its statement of the condition of the blast furnaces on August 1, sums up the totals as follows:

Fuel.	In Blast. No.	In Blast. Weekly capacity.	Out of Blast. No.	Out of Blast. Weekly capacity.
Charcoal	69	13,248	103	11,666
Anthracite	92	27,846	108	27,498
Bituminous	119	77,408	103	49,878
Total	280	118,502	314	89,042

"The table shows that the number of furnaces in blast was 280, or 3 less than the number in blast on July 1. The number of bituminous furnaces in blast shows no change; there is a decline of 4 in the number of anthracite furnaces blowing, and a gain of 1 in charcoal. The weekly capacity of the furnaces in blast was 118,502 tons, compared with 115,672 tons on July 1—an increase of 2,830 tons. The increase was confined to the charcoal and the bituminous furnaces, as follows: Charcoal—increase, 495 tons; bituminous—increase, 2,665 tons; anthracite—decrease, 330 tons.

"The appended table shows the number of furnaces in blast August 1, 1888, and August 1, 1887, with their weekly capacity:

Fuel.	Aug. 1, 1888. No.	Aug. 1, 1888. Weekly capacity.	Aug. 1, 1887. No.	Aug. 1, 1887. Weekly capacity.
Charcoal	69	13,248	80	14,396
Anthracite	92	27,846	127	35,278
Bituminous	119	77,408	120	70,855
Total	280	118,502	327	120,529

"Since January 1, 1888—seven months—there has been a decrease of 61 furnaces in blast, the decrease in weekly capacity being 22,218 tons."

CATECHISM OF THE LOCOMOTIVE.

(Revised and enlarged.)

BY M. N. FORNEY.

(Continued from page 376.)

CHAPTER XIII.—*(Continued.)*

QUESTION 376. *What are the principal causes which affect the form of the diagram?*

Answer. 1. The friction of the steam in the pipes and ports.

2. The variable size of the openings of the steam-ports as caused by the gradual motion of the side-valve.

3. The action of the internal surfaces of the cylinder in causing condensation and partial re-evaporation of some of the entering steam.

4. The steam contained in the clearance spaces which affects the curve of expansion.

5. The gradual opening of the exhaust-port, which makes it necessary to release the steam too early in the stroke.

6. The friction of the exhaust passages, which increases the back pressure.

7. The clearance spaces, which, combined with the unavoidable nature of the action of a slide-valve driven by a link-motion and the momentum of the moving parts, make compression necessary.*

QUESTION 377. *How can we determine whether the steam is distributed in the cylinders to the best advantage, and how can we discover the fault, if there is one, in the link-motion?*

Answer. The indicator will show the action of the steam in the cylinder, and motion-curves drawn with the instrument described in answer to Question 192 will show the exact movement of the valve. By comparing the indicator diagram with the motion-curves, the one will show the defects in the other.†

QUESTION 378. *To what extent can the movement of the valve be modified by alterations in the proportions of the link-motion?*

Answer. The motion of the valve is susceptible of an almost infinite number of changes, by different variations and combinations of proportions of the working parts of the link motion. These changes are, however, limited by the general laws which govern the motion of eccentrics, and therefore cannot influence the motion of the valve beyond certain limits. Hardly any variation can be made either in the proportions or arrangement of the working parts which will not have some influence upon the movement of the valve. Aside from the proportions of the valve itself, which have already been discussed, the throw of the eccentrics, the length of the rods and of the link, the point of connection of the rods with the link, the point of suspension, the position of the lifting-shaft, the length of the arms, the length and position of the rocker-arms, will each of them effect the distribution of steam. The number of combinations of all these different proportions is, of course, almost infinite, and therefore any full discussion of them will be impossible here.

QUESTION 379. *What are the most important points which require attention in designing a link-motion?*

Answer. It should be proportioned so that—

1. The lead and the period of admission should be the same for each end of the cylinder, for each point of cut-off, and, if possible, in back as well as forward gear.

2. The width of opening for both admission and exhaust should be as large as possible when steam is cut off short.

3. The exhaust or pre-release should occur early enough and be maintained long enough to reduce back-pressure as low as possible.

QUESTION 380. *In designing valve-gear how is it usually tested?*

Answer. Usually a full-sized model is made, the various parts of which are made adjustable, so that the proportions and position of the different parts may be varied, so that the best possible movement of the valve may be obtained. If mechanism for drawing diagrams of the motion of the valve similar to that illustrated in fig. 222 is added to the model, the action of the valve gear can be completely delineated.

QUESTION 381. *How can the lead and periods of admission of a slide-valve be equalized at each end of the stroke of the piston?*

Answer. It is impossible to make the periods of admission absolutely alike for every point of cut-off in both fore and back gear. It is, therefore, customary to disregard the back gear, as

* Questions 375 and 376 were suggested by George C. V. Holmes's excellent book on the steam-engine, and the answers thereto were in substance taken therefrom.

† See description of Richards's Improved Steam-Engine Indicator, with directions for its use, by Charles T. Porter, London.

engines are worked but little with the link in that position. Even for forward gear the periods of admission cannot be made exactly alike for each end of the cylinder and for each point of cut-off, and therefore it is usual to make the periods of admission alike for half-gear forward, in which position the link is worked most.

The periods of admission for the front and back ends of the cylinder can be changed most in relation to each other by altering the position of the point of suspension on the link. This can be done either by moving this point up or down, or horizontally. Usually links are suspended from a point halfway between the points of connection of the eccentric-rods and from ¼ to ⅜ in. back of the center line of the slot in the link. A somewhat better distribution can be secured by suspending them about

Fig. 246.

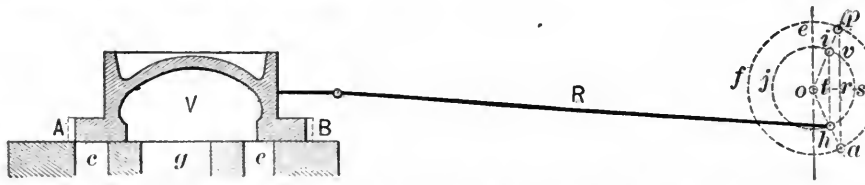


Fig. 247.

3 in. above the center, but the suspending-links must then be made so short that they are subjected to very great strains by the motion of the link, and this evil is usually considered much greater than the advantage which is gained thereby in the more equal distribution. The point at which the upper end of the suspension-link is hung also influences the relative amount of admission front and back. This point, of course, varies as the end of the lifting-arm is raised or lowered. The best position for the lifting-shaft and the length of its arm can be determined, perhaps, most satisfactorily by placing the link in full gear forward, then moving the point of suspension of the upper end of the link-hanger horizontally, so that the front and back admission will be alike, and then marking this position. The same process should then be repeated for half-gear and for the shortest point of cut-off. If the position of the lifting-shaft and the length of its arm are then so arranged that the end of the latter

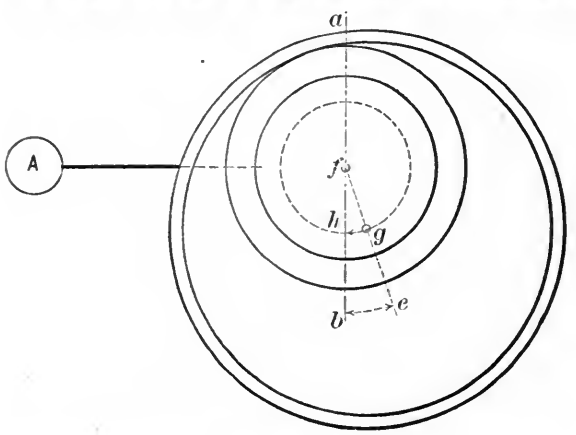


Fig. 245.

will move through the three points which have been thus determined, the admission will be very nearly equal for each end of the cylinder. Usually, however, it is impossible to arrange the shaft and arm so that they will conform exactly to these conditions, and therefore an approximation is made which will come as near as possible to what is required. It may be stated, however, that the lifting-shaft should be kept as low as possible, so as not to interfere with the eccentric-rods. In some cases the shaft has been suspended from the boiler, so that the outside eccentric-rod would work past or over the end of the lifting-shaft, thus allowing the latter to be located lower than would otherwise be possible.

QUESTION 382. *Which parts of the link-motion have the greatest influence on the distribution of steam?*

Answer. The lap of the valve and the throw of the eccentrics. The effect of any change of these upon the distribution is very similar to that produced if a single eccentric is used, which was explained in the answers to Questions 120 and 121.

QUESTION 383. *What is the effect upon the admission of increasing the throw of the eccentrics with the same lap?*

Answer. As already explained, the effect is to increase the period of admission, or, in other words, to cut off later in the stroke, and also to increase the width of the opening of the steam-port or the distance which the valve throws over the port. This has an important influence upon the admission, when the link-motion is used.

QUESTION 384. *What is meant by the angular advance of the eccentrics?*

Answer. It is the angle which a line, *e f*, fig. 245, drawn through the center *f* of the axle and the center *g* of the eccentric makes with a vertical line, *a b*, also drawn through the center of the axle when the crank is on one of the dead-points or centers. Thus in fig. 245 the crank-pin *A* is represented on the front center. In order to give the valve the necessary lead the eccentric must be moved back of the vertical line *a b*. The angle *b f e* which the line *e f* (drawn through the center *g* of the eccentric and *f* of the axle) makes with the vertical line is called the *angular advance*.

QUESTION 385. *What is meant by linear advance?*

Answer. By linear advance is meant the distance which the valve has moved from its middle position at the beginning of the stroke of the piston. This, when the two rocker-arms are the same length, is the same as the distance *g h* of the center of the eccentric *g* from the vertical line, *a b*, fig. 245.

QUESTION 386. *Why does the cut-off occur earlier with an eccentric having a short throw than with one which gives more travel to the valve?*

Answer. Because it is necessary to give the eccentric with the short throw more angular advance—that is, it must be set "farther ahead" in order to give the valve the required lead. This is illustrated in fig. 246, in which a section of a valve, *V*, and ports, *c*, *g*, and *e*, are represented. In order to simplify the diagram as much as possible the rocker is left out and the valve is supposed to be moved by the rod *R* directly from the center *a* of the eccentric.* The effect of the angularity of the connecting-rod and eccentric-rod is also neglected. The circle *a b e f* represents the path of the center of an eccentric having 5-in. throw, and *h s i j* the path of one having 3½-in.-throw. In order to give the valve the required lead, which is supposed to be just line-and-line at the beginning of the stroke, the linear advance of the valve must be equal to the lap, or ⅞ in. If, therefore, we draw a line, *p a*, parallel to the vertical center line, *e k*, and ⅞ in. from it, the intersection of *p a* at *a* and *h* with the paths of the eccentric will be the centers of the eccentrics. If through these centers and the center of the circle, lines *o a* and *o h* be drawn, the angles *k o q* and *l o m*, which they make with the vertical *e k*, will represent the angular advance. It will be seen from these lines, and by comparing these two angles, that in order to give the valve the required lead, it is necessary to give the eccentric with the small travel more angular advance than is necessary for the one with the larger throw. It is obvious, too, that when the center of the larger eccentric has reached the point *b* the valve will have received its greatest travel, and that when it reaches *p* the steam-port *e* will again be closed or the steam cut off. If the small eccentric is employed, the valve will have its maximum travel when the center *h* reaches *s*, and the port will be closed when it reaches *i*. By drawing lines *o p* and *o n* through *i* and *p*, it will be seen that from the beginning of the stroke until the steam is cut off, if the large eccentric is employed, it, and consequently the shaft and crank, must move over an angle measured by the arc *q t p*. If the small eccentric is used, it and the crank must move through an angle measured by the arc *u t n*. In other words, the crank must turn a considerably greater distance before steam is cut off with an eccentric having a large than with one having a small throw.

* It will be seen that this causes the position of the center of the eccentric to be reversed.

It is also quite obvious from fig. 246 why the port is opened a shorter distance with a small than with a large eccentric. The distances *o s* and *o b* are equal to half the throws of the eccentrics, or 1¾ and 2½ in. The linear advance *o r* is in both cases ⅞ in., and therefore after the port begins to open the valve will be moved by the small eccentric, a distance which is equal to 1¾ − ⅞ = ⅞ in., and by the large one 2½ − ⅞ = 1⅝ in.

QUESTION 387. *What is the effect on the admission of giving an eccentric with a small throw the same angular advance as one with a large throw, and then reducing the lap of the valve so that the lead will be the same in both cases?*

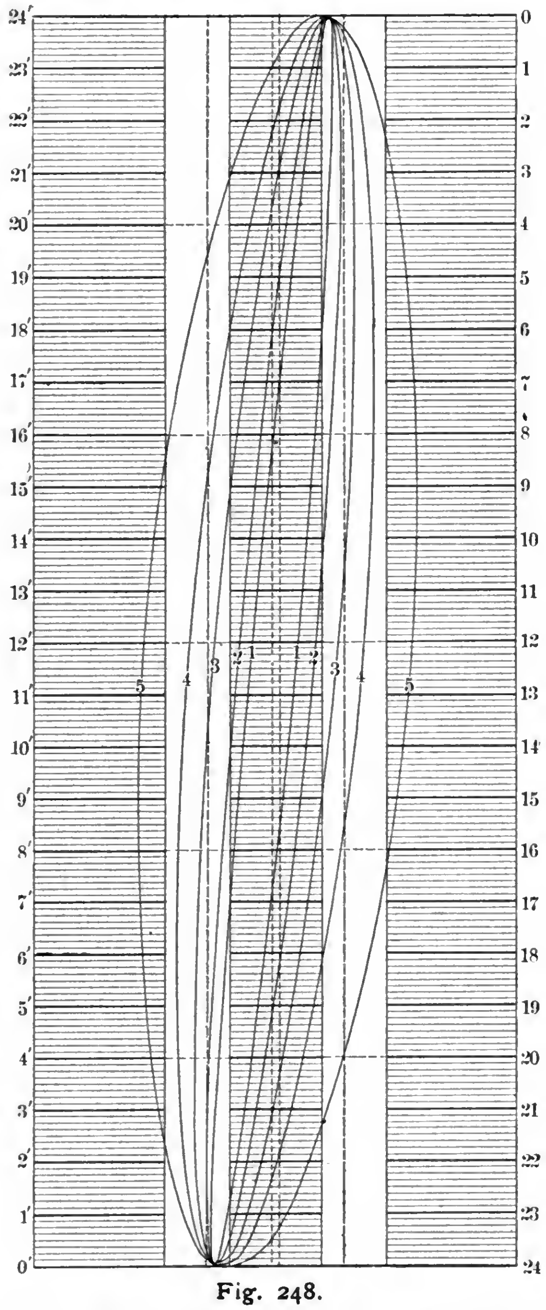


Fig. 248.

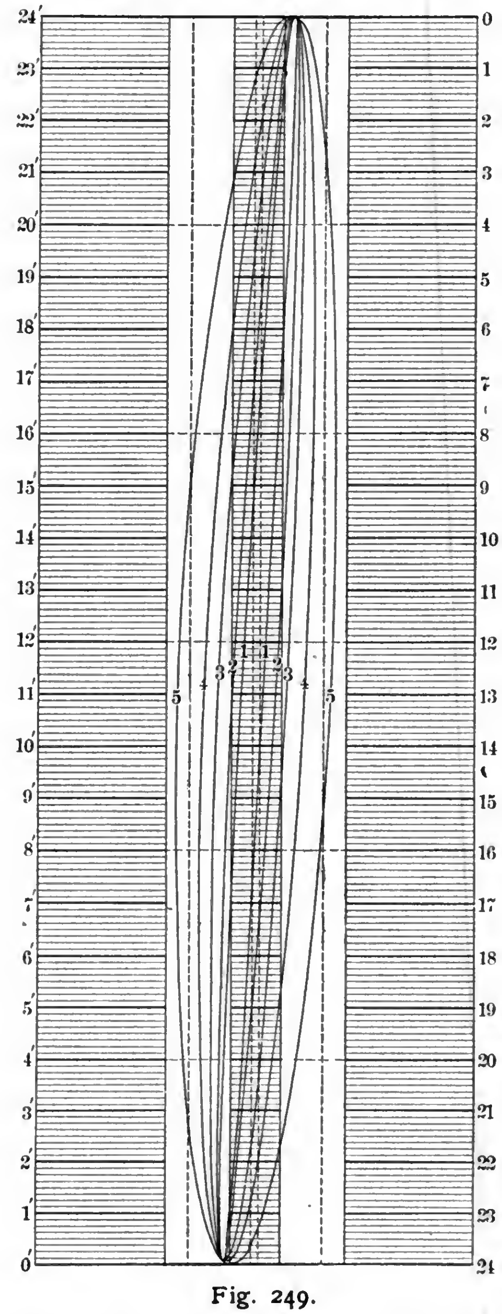


Fig. 249.

Answer. The admission and the cut-off will then occur at the same points of the stroke, but the ports will not be opened so wide. This is illustrated in fig. 247, in which the paths of two eccentrics having the same throw as those in fig. 246 are represented. The centre *a* of the larger eccentric is represented in the same position in fig. 247 as in fig. 246. If a line is drawn from the center of the larger eccentric to *o*, the center of the axle, and if the center *h* of the smaller eccentric is located on the intersection of this line with the circle *h s i j*, which represents its path, then the smaller eccentric will have the same angular advance, but the linear advance measured by the distance *o t* will be only ⅝ in. If the valve has the same lap as in fig. 246, its steam edges at the beginning of the stroke—if the small eccentric is employed—will occupy the position represented by the dotted lines *A* and *B*. If these edges are cut off, as shown by the full lines and shading, then the valve will have the same lead as in fig. 246. It is obvious, too, that if the smaller eccentric has the same angular advance it will reach the point *v*, at which, with the reduced lap, the steam will be cut off, at the same time that the center *a* of the large eccentric will reach *p*, at which point it cuts off the steam with the valve having the large lap. There is, however, this difference in the distribution, that in the one case the valve opens the port a distance equal to *t s*, and in the other a distance equal to *r b*. ∴ As *o t* is equal to the linear advance of the small eccentric, or ⅝ in., and *o s* to half the throw of the eccentric, or 1¾, *t s* is equal to 1¾ − ⅝ = 1⅛ in. The distance *r b*, as shown above, is equal to 2½ − ⅞ = 1⅝ in., so that the effect produced upon the admission of using an eccentric with a small throw and corresponding amount of lap is, that the ports are not opened so wide as with an eccentric having a larger throw.

QUESTION 388. *How do eccentrics with a short throw and valves with a corresponding amount of lap affect the admission with a link-motion as compared with eccentrics having a larger amount of throw and greater lap of valve?*

Answer. The chief difference is that the ports are not opened so wide for the same period of admission. Thus a series of motion-curves is shown in fig. 248, drawn with a model of a link-motion like that illustrated in fig. 222. The eccentrics had 5-in. throw, and the valve ⅞-in. lap outside and $\frac{1}{16}$-in. inside. Fig. 249 represents a series of curves, drawn with the same arrangement of valve-gear, excepting that the eccentrics had 3½-in. throw and the valve ½-in. lap. In both cases the curves represent the motion of the valve when cutting off at the same point

of the stroke. The following table will show the relative amount of opening of the port.

Point of Cut-Off.	Width of Opening of Steam-Port.	
	Eccentric 5-in. throw.	Eccentric $3\frac{1}{2}$-in. throw.
6 in.	$\frac{7}{32}$ in.	$\frac{5}{32}$ in.
10 "	$\frac{11}{32}$ "	$\frac{7}{32}$ "
15 "	$\frac{5}{8}$ "	$\frac{3}{8}$ "
18 "	$\frac{31}{32}$ "	$\frac{11}{16}$ "
21 "	$1\frac{1}{4}$* "	$1\frac{1}{32}$ "

* The valve throws over the steam-port $\frac{5}{8}$ in. at this point.

It will be seen from this that the eccentric with 5-in. throw gives a greater width of opening for every point of cut-off than the one with $3\frac{1}{2}$-in. throw. For the higher admissions this is not important, but when steam is cut off short it will be observed that the width of the opening is very small. At high speeds the small opening is a great disadvantage.

QUESTION 389. *Has it been determined what amount of opening is required for given speeds of the piston?*

Answer. Not with any degree of accuracy. It is customary to make the area of the ports about one tenth that of the piston. It is certain, however, that with steam-ports of this proportion, excepting at high speeds, an opening considerably less than their whole area is sufficient to maintain steam nearly equal to boiler pressure in the cylinders. One of the defects of the link-motion is that the opening of the port is very small when the steam is cut off short. It is best, therefore, to secure the largest practicable opening of the ports for the lower points of cut-off.

QUESTION 390. *What are the proportions of the valves and eccentrics used in the ordinary practice in this country?*

Answer. Excepting for very light locomotives the maximum travel varies from $4\frac{1}{2}$ to $5\frac{1}{2}$ in., the outside lap from $\frac{5}{8}$ to $1\frac{1}{4}$ in., the inside lap from $\frac{1}{16}$ to $\frac{3}{16}$ in., and the lead in full gear from $\frac{1}{16}$ to $\frac{1}{8}$ in.

QUESTION 391. *What should be the width of the bridge between the steam and exhaust ports?*

Answer. It is usually made about the same thickness as the sides of the cylinder, in order to secure a good casting; but sometimes it is necessary to make it wider, in order to prevent steam from escaping from the steam-chest into the exhaust, which is apt to be the case if a valve has little lap and a long travel.

QUESTION 392. *What determines the width of the exhaust-port?*

Answer. The throw of the valve. This will be clear if we refer to fig. 52. The port *g* should be wide enough so that when the valve is at the end of its travel the opening *h i* of the exhaust-port is not contracted too much. If this opening is not wide enough it will prevent the free escape of the exhaust-steam and increase the back pressure.

It is, therefore, best to make the exhaust-port so wide that with the greatest travel of the valve the width of its opening will be nearly equal to the width of the steam-ports.

QUESTION 393. *What effect does the steam have on a slide-valve?*

Answer. It exerts a pressure nearly or quite equal to the area of the top of the valve multiplied by the pressure of steam on a unit of that area. Thus a valve when outside dimensions are 9×18 in. would have an area of 162 square in. If a boiler pressure of 140 lbs. per square in. is exerted on the whole of this area it would be equal to $162 \times 140 = 22,680$ lbs. The actual pressure exerted by the steam on the valve is, however, very irregular, as during some portions of the stroke the steam in the ports under the valve exerts an upward pressure, which opposes that on top. The pressure on top is also influenced by the fit of the valve to its seat. If it is not steam-tight more or less steam will get between the valve and its seat, and thus counteract the pressure on top, whereas if the valve is perfectly steam-tight, no such action will occur. In any event, however, the pressure on top of slide-valves will be very great, and much power is required to move them when the engine is working, unless the pressure is relieved in some way.

QUESTION 394. *How is the pressure on slide-valves relieved?*

Answer. By excluding the steam from the top of the valve so that it cannot exert its pressure on it. This is done by means of packing on the top of the valve, which bears against a plate above. This packing consists either of rings or straight strips of metal, *p p*, fig. 250, but the latter are arranged in rectangular form and held in grooves on top of the valve. These bear against a plate, *P*, attached to the steam-chest cover, which is planed and scraped so that the surfaces of contact of the packing against the plate are steam-tight. The packing is also made steam-tight where it is in contact with the valve, and is held up against the plate by springs underneath. Steam is thus excluded from the top of the valve at *a a*. A hole, *o*, in the valve allows any steam which might leak past the packing to escape into the exhaust cavity *V*. A relief valve *R* is attached to the steam-chest to admit air and prevent it from being sucked in through the exhaust-pipes, when steam is shut off, and the action of the piston creates a partial vacuum in the steam-chest. If air was sucked in through the exhaust pipes cinders and other gritty substances would be drawn in with it, and would be liable to cut the valve-face and the inside of the cylinder. When a vacuum is produced in the steam-chest the valve is raised up by the pressure of the air below, and it flows in through openings underneath, as indicated by the arrows. The valve represented by the engraving is what is known as Richardson's balanced valve.

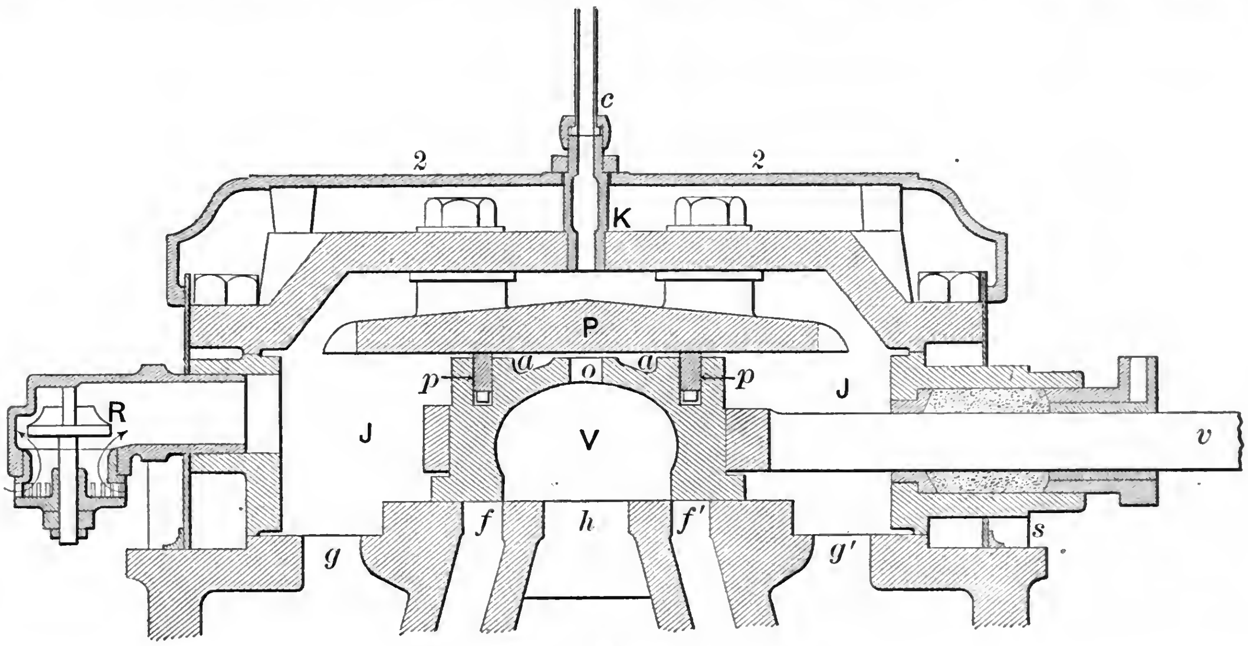


Fig. 250.

QUESTION 395. *How are the notches in the sector arranged?*

Answer. They are often arranged so that the steam will be cut off at some full number of inches of the stroke when the reverse-lever is in each one of the notches. They are then located so that the steam will be cut off at 6, 9, 12, 15, 18, and 21 inches, or at 6, 8, 10, 12, 15, 18, and 21 inches of the stroke. A notch is also placed so as to hold the link in mid-gear. In other

cases as many notches as there is room for are put into the sectors. The latter seems to be much the best plan, as it gives more gradations in which the valve-gear can be worked, and it is a matter of no consequence whatever in the working of an engine whether the steam is cut off at some full or some fractional number of inches of the stroke.

QUESTION 396. *Where is the reverse lever located and how is it constructed?*

Answer. It is located in the cab and above the *foot-board* * 93, as shown in Plates III and IV. It consists of a lever, 20, 21, with the fulcrum at the lower end. The *reverse-rod* 19, 21, which connects the lever with the vertical arm 18 of the lifting-shaft, is attached above the fulcrum of the reverse lever. Fig. 251 represents a side view of the lever on an enlarged scale and with some of the details attached, which are omitted on Plates III and IV. *S S'* are two curved bars, which in this

The reverse rod *G G'* is connected to the lever at *G'*, and is part of the rod indicated by the same letter in fig. 198.

QUESTION 397. *How long should the reverse-lever be?*

Answer. The lever should be sufficiently long, so that in throwing the link from full gear forward to full gear backward the handle *H* will move *not less* than four times the distance that the link is moved. It is much better to give the end of the handle five or even six times the motion of the link, as there will then be a much easier action in reversing the engine. This will also make it possible to use longer sectors and give room for more notches.

QUESTION 398. *What provision is made in the reversing gear for overcoming or neutralizing the weight of the link and other parts of the valve-gear?*

Answer. Their weight is counterbalanced by the pressure of a spring of some kind. In fig. 198 the case *H* contains a

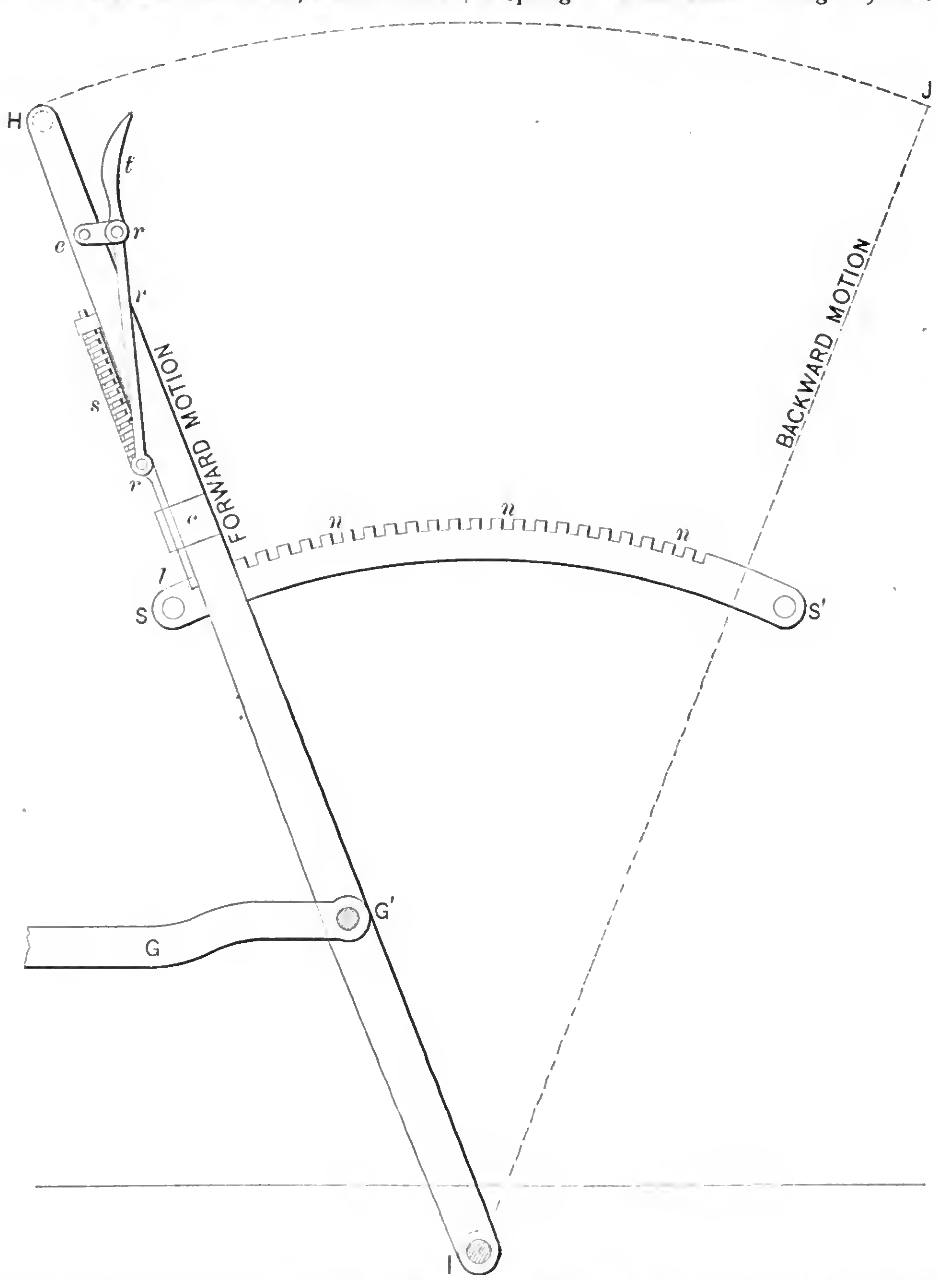


Fig. 251.

country are usually called *quadrants*, but in England are called (and more properly) *sectors*. These are placed on each side of the reverse-lever and are fastened to some portion of the engine. They have notches, *n n n*, cut in them to receive the *latch l*, which slides in a clamp, *c*, and holds the reverse-lever in the notches in which it is placed. This latch is operated by a *trigger*, *t*, which is grasped by the locomotive runner when he takes hold of the handle *H* of the reverse-lever. The trigger works on a pin, *e*, as a fulcrum, and is attached to the latch by a rod, *r r*. When the trigger is pressed up against the handle, the latch is raised out of the notches by the rod *r r*, and is pressed into them again by the spring *s* when the trigger is released.

spiral spring (of the form of a watch spring); the inner end is fastened to the shaft *A*, and the outer end to a portion of the case which can be turned around the shaft. By this means the tension of the spring can be adjusted, and the case is then held in the required position by a bolt shown below the shaft *A*. Different kinds of springs are used for this purpose, and sometimes are attached to the reverse-lever instead of to the lifting-shaft.

QUESTION 399. *What is meant by "setting" a slide-valve?*

Answer. It is to fasten the eccentrics in the right position on the axle and to adjust the length of the eccentric-rods and valve-stem so that the valves will give the required distribution of steam.

QUESTION 400. *How are the valves of a locomotive set?*

Answer. After the wheels, axles, main connecting-rods and valve-gear are connected together, put the rocker-arm in its

* The *foot-board* 93, plates III and IV (see JOURNAL for May), is a platform for the locomotive runner and fireman to stand on, and is located at the back end of the engine.

middle position, and lengthen or shorten the valve-stem, so that the valve will then be in the center of the valve-face. Then place the crank on the forward center and the full part of the forward motion eccentric above and that of the backward motion eccentric below the axle, and fasten them to the axle temporarily by tightening up the set-screws. Then throw the link down until the block comes nearly opposite to the end of the eccentric-rod, and turn the wheels,* and at the same time observe whether the travel of the valve is equal to the throw of the eccentric and also whether it travels equally on each side of the center of the valve-face. If its travel is greater than the throw of the eccentric, raise the link up; if less, lower it down until the two are just equal, and then mark the position for the notches on the sectors or quadrants to receive the latch of the reverse-lever. If the valve does not travel equally on each side of the center of the valve-face, either lengthen or shorten the eccentric-rod, as may be necessary. Repeat this operation for the backward motion, by raising the link up until the block is opposite the end of the lower eccentric-rod. After having done this, go over the whole process again to see whether it is all correct. Now with the crank on the forward center and the link in full gear forward, loosen the set-screws in the forward eccentric, and move it around the axle so that the valve will have the required lead and then fasten it again. Now raise the link up into full back gear, and set the backward eccentric in the same way. Then turn the wheels so as to bring the crank on the back center, and observe whether the lead is correct for the back end of the cylinder. If it is not, lengthen or shorten the eccentric-rod so as to make the lead alike at both ends, and if then it is too much or too little, it can be increased or diminished by moving the eccentrics on the axle.

Great care must be taken in setting valves to be sure that the cranks are exactly on the centers or dead-points, and it is impossible to set them in that position with sufficient accuracy from the motion of the piston or cross-head, and therefore the centers of the crank-pins should always be set so as to conform to a line drawn through the center of the cross-head pin, crank-pin, and the axle.

When the valves are set it should also be noticed whether the axle-boxes (whose construction will be explained hereafter) are in the middle of the jaws, and if not they should be moved to that position by driving wooden wedges between them and the frames, either above or below, as may be required. The position of the boxes has a very material influence on the valve-gear.

If it is intended to lay off the notches on the sectors so as to cut off steam at certain definite points of the stroke, these points should be laid off in the guides from the motion of the cross-head. The latter being placed in any of the required positions at which steam is to be cut off, the reverse-lever should then be moved so that the link will just close the admission port. The lever can then be clamped to the sectors, and the wheels turned so as to show whether its position is correct for each end of the stroke. It has been mentioned before that it is impossible to get the ordinary link-motion to cut off at exactly the same points at both ends of the cylinder, but a very close approximation can be made by proportioning the different parts properly. As has already been stated, it is a much better plan to put as many notches in the sectors as possible than to locate them for certain definite points of the stroke.

In setting the valves of locomotives, care must be taken to turn the wheels *forward* for the *forward motion* and *backward* for the *backward motion*.

After the valves are set the position of the eccentrics on the shaft should be marked, so that in case they become loose on the road they can easily be set again. It is usual, too, to mark the position of the valves with center-punch marks on the valve-stem and on the stuffing-box of the steam-chest, so that with a gauge made for the purpose the position of the valve can be determined without taking off the steam-chest cover.

In some cases the eccentrics are keyed on, which is done after their position is determined by setting the valves. The ends of the set-screws which are used to fasten the eccentrics should be cup-shaped and case-hardened, so as to hold as securely as possible to the axle when they are screwed down.

After the valve is set on one side of the engine that on the other side should be tested for each point of cut-off so as to be certain that the two valves work alike. It sometimes happens that the link-hanger or suspension link on one side must be either lengthened or shortened, so that the two links will occupy the same relation to their rocker-pins.

If the valves are set when the engine is cold they should be tested after it has been fired up, as the expansion of the parts may affect the action of the valves.

* This can be done by moving the engine on the track or by raising it off its wheels, so that the latter can be turned without moving the former. In some shops a pair of rollers is put in the track, so that by placing the driving-wheels on them they can be turned without any difficulty.

CHAPTER XIV.

ADHESION AND TRACTION.

QUESTION 401. *What is meant by the "adhesion" of a locomotive?*

Answer. It is the resistance which prevents or opposes the slipping of the driving-wheels on the rails, and is due to the friction of the former on the latter.

QUESTION 402. *On what does the amount of this friction depend?*

Answer. Like all friction, it depends upon the weight or pressure of the surfaces in contact, and consequently upon the load which rests on each wheel. It also depends upon the condition of the rails, and probably to some extent upon the material of which they and the tires on the wheels are made.

QUESTION 403. *How much force is required to make the driving-wheels of a locomotive slip on an ordinary railroad track?*

Answer. The force required to make them slip will, as already stated, vary very much with the condition of the rails. If they are quite dry and clean it will require a force equal to about one-fourth the weight on the wheels. That is, supposing we have a wheel, *A B*, fig. 252, attached to a frame which is fastened so that it cannot move, and that the wheel rests on a rail and is loaded with say 12,000 lbs., if now a rope or chain could be attached at a point, *B*, exactly at the tread of the wheel, and carried over a pulley, *C*, then it would require a weight, *D*, of about 3,000 lbs. attached to the end of the rope to make the wheel slip. If the rails were sanded, the adhesion would be somewhat greater, and if they were wet or muddy or greasy, considerably less. The proportion of the adhesion to the weight in the driving-wheels is about as follows:

On dry-sanded rails it is equal to *one-third*.

On perfectly dry rails, without sand, it is *one-fourth*.

Under ordinary conditions, without sand, or on wet-sanded rails, *one-fifth*.

On wet or frosty rails, *one-sixth*.

With snow or ice on the rails, the adhesion is still less.

Of course the total weight on all the driving-wheels must be taken in calculating the adhesion. Thus, if a locomotive has four driving-wheels, and each one of them bears a load of 12,000 lbs., then the total weight on the driving-wheels, or *adhesive weight*, as it is called, will be $12,000 \times 4 = 48,000$ lbs., and the adhesion will be

$$\frac{48,000}{5} = 9,600 \text{ lbs.}$$

QUESTION 404. *What is meant by the tractive power of a locomotive?*

Answer. It is the force with which the locomotive is urged in a horizontal direction by the pressure of the steam in the cylinders, and which therefore tends to move the locomotive and draw the load attached to it.

The tractive power is due to the pressure of steam on the pistons, and therefore its amount is dependent upon the average steam pressure in the cylinders on the area of the piston, and also on the distance through which the pressure is exerted, or, in other words, on the stroke of the piston. Thus if we have a cylinder 17 in. in diameter and two feet stroke, and an average steam pressure of 50 lbs. per square inch, then, as the area of such a piston would be 227 square inches, the average pressure on it would be $227 \times 50 = 11,350$ lbs., and as each piston moves through four feet during one revolution of the wheels, the number of foot-pounds of energy exerted by it would be $11,350 \times 4 = 45,400$, and for the two cylinders of a locomotive double that amount, or 90,800 foot-pounds. If the driving-wheels are 5 ft. in diameter, their circumference will be 15.7 ft., and therefore the locomotive will move that distance on the rails during one revolution, if the wheels do not slip. The 90,800 foot-pounds of energy is therefore exerted through a distance of 15.7 ft., and therefore

$$\frac{90,800}{15.7} = 5,783 \text{ lbs.},$$

which is the force exerted through each foot that the circumference of the wheel revolves and the locomotive moves. If the wheels were only half the diameter, or $2\frac{1}{2}$ ft., then their circumference would be 7.85 ft., and the tractive power would be

$$\frac{90,800}{7.85} = 11,566 \text{ lbs.},$$

or double what it was before. It will be seen, then, that the tractive force of a locomotive is dependent upon (1) the average steam pressure in the cylinders, (2) the area of the pistons, (3)

the stroke of the pistons, and (4) the diameter of the driving-wheels.

QUESTION 405. *How is the tractive power of a locomotive calculated?*

Answer. BY MULTIPLYING TOGETHER THE AREA OF THE PISTON IN SQUARE INCHES, THE AVERAGE STEAM PRESSURE IN POUNDS PER SQUARE INCH ON THE PISTON DURING THE WHOLE STROKE, AND FOUR TIMES THE LENGTH OF THE STROKE OF THE PISTON,* AND DIVIDING THE PRODUCT BY THE CIRCUMFERENCE OF THE WHEELS. The result will be the tractive power exerted in pounds. The adhesion must, of course, always exceed the tractive force, otherwise the wheels will slip.

QUESTION. 406. *How is the locomotive made to advance by causing the wheels to revolve?*

Answer. The pressure of steam in the cylinders is exerted in one direction against the piston, and in the opposite direction against the cylinder-head, as shown in fig. 252, in which the steam is represented by the dotted shading in the back end of the cylinder, and the direction of the pressure by the darts *s s*. The pressure against the piston is communicated by the connecting-rod to the crank-pin *E*, and that on the cylinder-head is exerted on the axle through the frame *F F'*, and the direction of the two forces is indicated by the two darts, *a* and *b*. We may now regard the spokes of the wheels as acting as levers, and assume that the fulcrum is either at the center *G* of the axle, or at *B*, the point of contact of the wheel with the rail.† It may be assumed that it is at the center *G* of the axle, and for the sake of even figures that the wheel is 6 ft. in diameter and cylinders have 2-ft. stroke. It will also be supposed that the engine is supported, so that the wheels do not touch the rails, and that a chain or rope passing over a pulley, *C*, is attached to the wheels at *B* and with a weight at *D*. We now have a force, *a*, of say 10,000 lbs. exerted on the crank-pin, or at the end of the short arm *E G* of the lever *E G B*. As *E G* is 1 ft. and *G B* 3 ft. long, 10,000 would be balanced by

$$\frac{10{,}000 \times 1}{3} = 3{,}333 \text{ lbs.}$$

at *B*. In other words, it would require 3,333 lbs. suspended from the chain at *D* to resist the strain at *E*. But when this is the case, the pressure of the axle at the fulcrum, in the direction of the dart *c*, is equal to the pressure against the crank-pin *E* added to that exerted by the weight *D* at *B*, or 10,000 + 3,333 = 13,333 lbs.

As the pressure against the axle in the opposite direction, *b*, is only 10,000 lbs., there will be an unbalanced force of 3,333 lbs. acting in the direction of the dart *c*, and tending to move it that way. As the axle is attached to the locomotive frame, this force will, of course, have a tendency to move the whole machine, and is really the tractive force of the engine.

If, on the other hand, we regard the point of contact *B* of the wheel with the rail as a fulcrum, we have a force of 10,000 lbs. acting at *E* against a lever, *E G B*, 4 ft. long. The force which this would exert against the axle *G* would be calculated by multiplying 10,000 by the whole length of the lever, and dividing by its long arm *G B*, so that we will have

$$\frac{10{,}000 \times 4}{3} = 13{,}333 \text{ lbs.}$$

exerted at *G*; and as the pressure exerted by the steam in the cylinder in the direction of the dart *b* is only 10,000, there would be an unbalanced strain of 13,333 − 10,000 = 3,333 lbs. acting against the axle in the direction of the dart *c*, or, in other words, there is 3,333 lbs. more of force pulling the axle forward than there is pushing it backward.

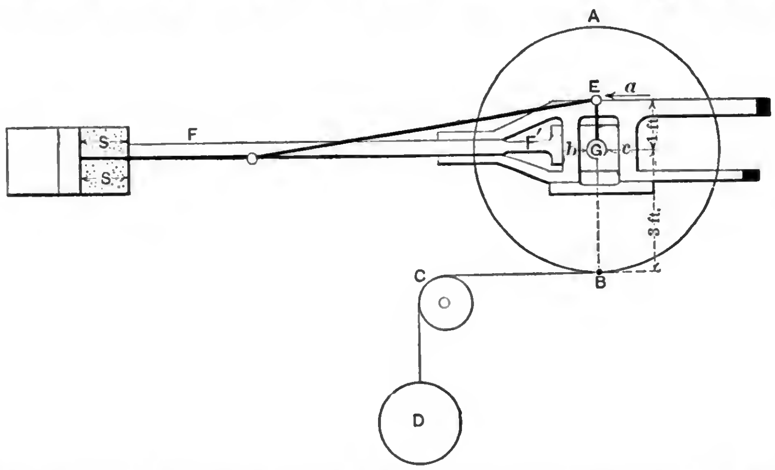


Fig. 252.

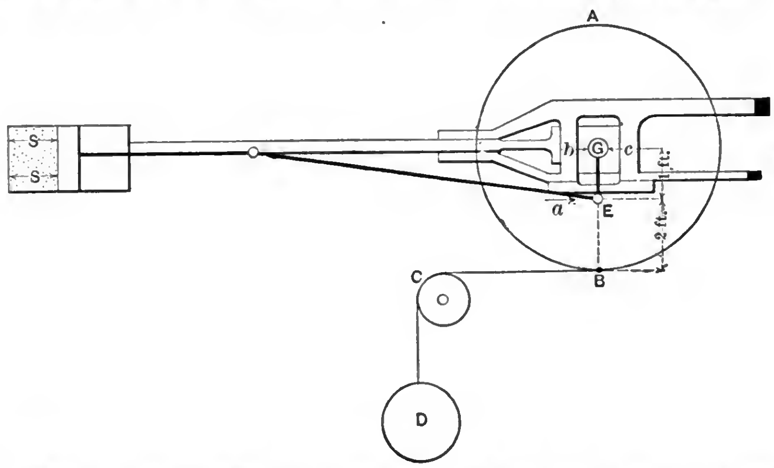


Fig. 253.

When the crank-pin is below the axle, in the position shown in fig. 253, then, if the center of the axle is regarded as the fulcrum, we have a pressure of 10,000 lbs. pushing against the front cylinder-head, which is transferred to the axle by the frames, and acts in the direction of the dart *c*, and we also have a pressure acting against the crank-pin *E* in the direction of the dart *a*. If *G* is the fulcrum, the pressure which the force $a = 10{,}000$ lbs. would exert at *B* would be calculated by multiplying it by the short arm *G E* of the lever, and dividing by *G B* its whole length—that is,

$$\frac{10{,}000 \times 1}{3} = 3{,}333 \text{ lbs.},$$

which is the tractive force exerted at *B*.

If, on the other hand, *B* is the fulcrum, then the force exerted in the axle *G* by the pressure of the piston on the crank-pin would be calculated by multiplying it by the length *E B* of its long arm, and dividing by its whole length *G B*, or

* This length may be taken in feet, inches, or any other measure, but in making the calculation the circumference of the wheels must be taken in the *same* measure as the stroke of the piston.

† The question whether the center of the axle or the point of contact with the rail is the fulcrum of the lever in this case has been the subject of much discussion and contention. As the word *fulcrum* means "a point about which a lever moves," it is believed that the dispute is due simply to a difference in the meaning assigned to the word fulcrum. If we regard the fulcrum as the point which is fixed in relation to the locomotive, then it is at the center of the axle; but if we refer it to the surface of the earth, then it is at the top of the rail.

$$\frac{10,000 \times 2}{3} = 6,667 \text{ lbs.}$$

exerted at *G* in the direction of *b*. But the pressure on the cylinder-head pulls against the axle *G* in the direction *c* with a force of 10,000, so that the excess of strain in the direction *c* will be equal to 10,000 − 6,667 = 3,333 lbs.

It will be seen, then, that it is immaterial which point is regarded as the fulcrum, as the result of the calculations is exactly the same.

It must not, however, be hastily supposed from what has been said that the total pressure against the axle can be greater than its resistance to the pressure. As soon as the one exceeds the other it will move. But supposing that it requires a force equal to 3,333 lbs. to draw a train coupled to the engine, as soon as the difference between the force exerted against the axle by the piston to move it forward and that which presses it back exceeds 3,333 lbs., the locomotive will move the train. If the force exerted continues to exceed the resistance the speed of the train will be accelerated, and thus the resistance which holds the engine back and that which pushes it forward will always be equal.

QUESTION 410. *Can the weight of these counterweights be calculated for any locomotive?*

Answer. It can probably be calculated, but it is an exceedingly complicated problem, and one about which there is much difference of opinion. The following rules are given in "Clark's Railway Machinery," and are, perhaps, sufficiently close to find a first approximation to the requisite position and weight of the counterweights; but the final adjustment should be made by trial. This can be done by suspending the locomotive by chains attached to the four corners of its frame, and setting the machinery in motion at the speed it is intended to run. By attaching a pencil to one or to each of the four corners of the frame, and arranging it so that it will mark on a horizontal fixed card, a diagram will be drawn, being usually an oval, which will show the amount and form of the oscillations. The counterweights can then be adjusted so that the diagram drawn by the pencil is reduced to the least possible size. When the adjustment is successful, the diameter of the diagram is reduced to about $\frac{1}{16}$ of an inch.* Another and simpler, but less accurate, way is to place a pail or other vessel filled with water on the front of the engine and run the locomotive on a smooth

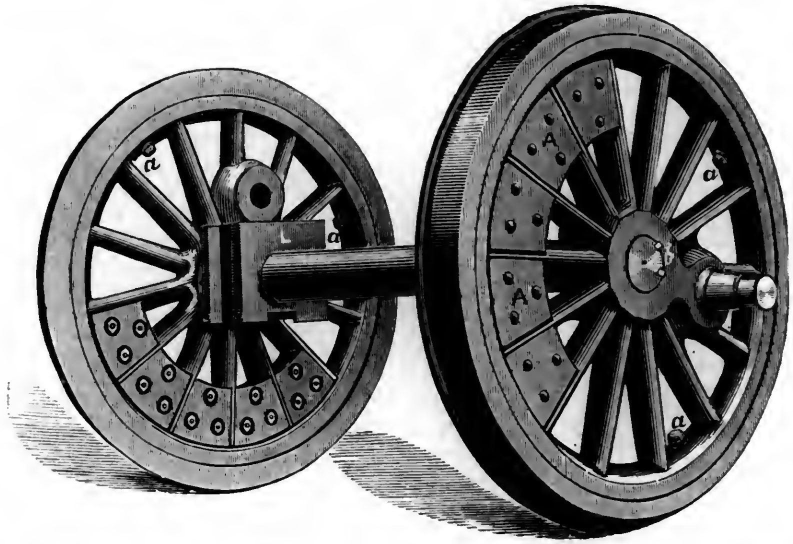


Fig. 254.

QUESTION 407. *Does the fact that the piston is working from the end of a longer lever E G' B, fig.* 252, *when the crank-pin is above the axle, enable the locomotive to start a heavier train than when the crank-pin is below the axle and the piston is working against a shorter lever, G E B, fig.* 253*?*

Answer. No; because, as has already been shown, the pressure against the axle is the same in both cases. It is, in fact, only during the forward stroke that the pressure on the crank-pin moves the engine forward. The forward pressure which is exerted by the crank-pin at the axle is then greater than that exerted against the latter in the opposite direction by the cylinder-head and frames. It is this excess of crank pressure which moves the engine and which is the tractive force during the forward stroke. During the backward stroke the piston is pushing the axle backward, and the pressure against the front cylinder-head is pulling it forward. The latter then exceeds the former, and the difference between the two is the force which moves the engine forward. As has been shown, this difference is the same in both positions of the crank, and therefore the locomotive cannot from this cause pull more when the crank is above the axle than when it is below.

CHAPTER XV.

INTERNAL DISTURBING FORCES IN THE LOCOMOTIVE.

QUESTION 408. *What are the internal disturbing forces in a locomotive?*

Answer. They are: 1, the momentum of the parts which have a reciprocating motion; 2, those due to the varying pressure of the steam on the cylinder-heads; 3, those caused by the thrust of the connecting-rods against the guide-bars; and 4, those produced by unbalanced revolving parts.

QUESTION 409. *How can the effects of these disturbing forces be neutralized?*

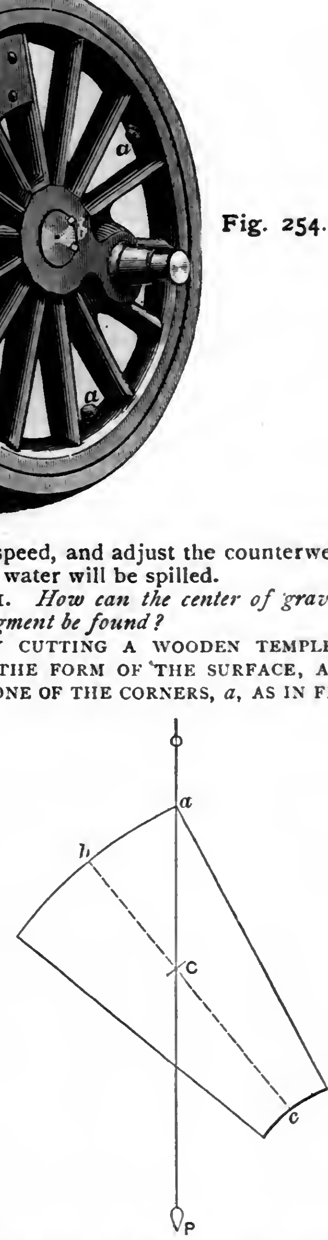
Answer. To some extent by putting counterweights, *A A*, fig. 254, in the driving-wheels opposite the crank-pins. Their motion will then be in the reverse direction to that of the parts attached to the crank-pins, and the motion of the counterweights will thus neutralize the disturbing influence of the reciprocating and other revolving parts.

track at a high speed, and adjust the counterweights so that the least amount of water will be spilled.

QUESTION 411. *How can the center of gravity of a counterweight in one segment be found?*

Answer. BY CUTTING A WOODEN TEMPLET OF UNIFORM THICKNESS TO THE FORM OF THE SURFACE, AND FREELY SUSPENDING IT BY ONE OF THE CORNERS, *a*, AS IN FIG. 255; A PLUM-

Fig. 255.



MET-LINE, *a P*, DROPPED FROM THE SAME POINT OF SUSPENSION IN FRONT OF THE TEMPLET, WILL INTERSECT THE CENTER LINE *b c* AT THE CENTER OF GRAVITY *C*.

QUESTION 412. *How can the center of gravity of a counterweight in three segments be found?*

Answer. FIND THE CENTER OF GRAVITY *C*, FIG. 256, OF ONE OF THE COUNTERWEIGHTS, AS ABOVE; THROUGH *C* STRIKE AN

* Rankine's Treatise on the Steam Engine.

arc from the center, a, of the wheel, crossing the center lines of the other segments at their centers, C' C''; draw C' C'' meeting A B at D, and set off D E, one-third

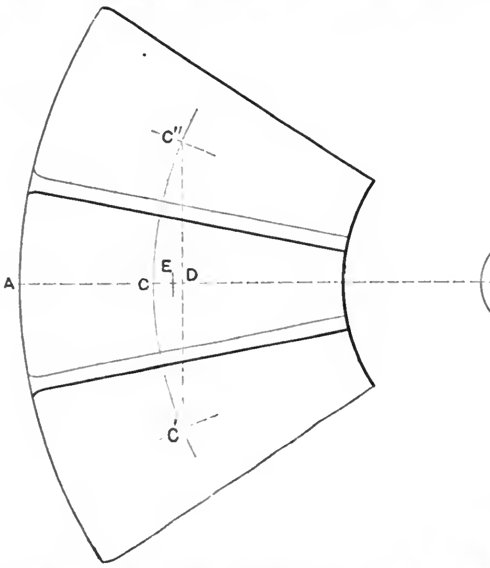


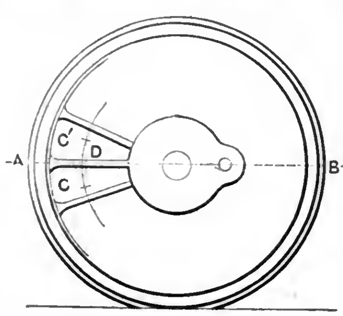
Fig. 256.

of the interval D C. Then E is the common center of gravity of the three segments.

Question 413. *How can the center of gravity of a counterweight in two segments be found?*

Answer. This is required when the crank is opposite to a spoke, as in fig. 257. Find the center of gravity, C, of one segment as before, and by an arc find the other center C'; draw C C', cutting A B at D, which is the common center of gravity.

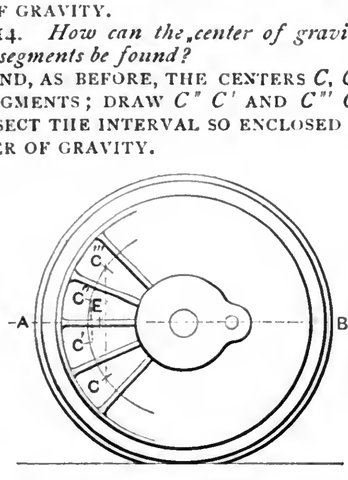
Fig. 257.



Question 414. *How can the center of gravity of a counterweight in four segments be found?*

Answer. Find, as before, the centers C, C', C'', C''', fig. 258, of the segments; draw C'' C' and C''' C, cutting the line A B; bisect the interval so enclosed at E for the common center of gravity.

Fig. 258.



Question 415. *How is the counterweight for outside cylinder engines with a single pair of driving-wheels calculated?*

Answer. Find the total weight, in pounds, of the revolving and reciprocating masses for one side—namely, the piston and appendages, connecting-rod, crank-pin, and crank-pin boss; multiply by the length of crank in inches, and divide by the distance in inches of the center of gravity of the space to be occupied by the counterweight. The result is the counterweight in pounds, to be placed exactly opposite to the crank.

Question 416. *How is the counterweight for outside-cylinder engines with coupled driving-wheels calculated?*

Answer. Find the separate revolving weights, in pounds, of crank-pin, crank-pin boss, coupling-rods and connecting-rod, for each wheel, also the reciprocating weight of the piston and appendages, and half the connecting-rod; divide the reciprocating weight equally between the coupled wheels, and add the part, so allotted, to the revolving weight on each wheel; the sums so obtained are the weights to be balanced at the several wheels, for which the necessary counterweight may be found by the preceding rule.

Question 417. *How do counterweights neutralize the disturbing effect of the revolving parts—that is, the crank-pins and their bosses, the back end of the main connecting-rod and the coupling-rod?*

Answer. These parts are all exactly balanced by equivalent weights placed opposite to the crank-pin, so that the wheels will be in a state of equilibrium at all points of their revolution. The horizontal motion of the reciprocating parts—that is, the piston, piston-rod, cross-head, and the front end of the main connecting-rod, may also be balanced by an equivalent weight placed opposite the crank.

Question 418. *How does a revolving weight counterbalance the action of the reciprocating parts?*

Answer. It does this because its horizontal movement is very nearly the same as that of the reciprocating parts. That is, while the piston is moving say 4 in., the counterbalance is moving very nearly the same distance horizontally,* but in the opposite direction, so that it acts as counterpoise to the reciprocating parts.

Question 419. *How does the counterbalance of the reciprocating parts disturb the action of the locomotive?*

Answer. As the counterbalance of the reciprocating parts revolves, and as their motion compensates for the horizontal movement alone of the counterbalance, its vertical motion is not counteracted, and therefore exerts a vertical disturbance when the locomotive is running, which has sometimes been called the "hammer-blow" of the counterbalance. Its action, however, does not resemble that of a hammer, the motion of which, in striking an anvil, for example, is stopped instantly.

Question 420. *What is the effect of the unbalanced vertical motion of the counterweight?*

Answer. The only effect is that due to the centrifugal force exerted by the unbalanced counterweight. Thus, supposing the weight of the revolving parts to be balanced on the wheel represented in fig. 254 to be 300 lbs., and that of the reciprocating parts to be 275 lbs., and that the center of gravity b of the counterweight C is 20 in. from the center of the axle, then, by the rules given, the weight of C should be equal to $\frac{275 + 300 \times 12}{20}$ $= 345$ lbs. At a speed of 50 miles an hour, a wheel 5 ft. in diameter would revolve 280 times per minute. The centrifugal force of a weight of 300 lbs. at the crank-pin, as calculated by the rule given in the answer to Question 158, would be:

$$300 \times 280^2 \times 1 \times .00034 = 7{,}997 \text{ lbs.}$$

The centrifugal force of the counterweight would be:

$$345 \times 280^2 \times 1.666 \times .00034 = 15{,}327 \text{ lbs.}$$

In fig. 259, therefore, the centrifugal force which the weight at the crank-pin would exert in the direction of the dart a would be equal to 7,997 lbs., and that of the counterweight C in the opposite direction, as indicated by the dart b, would be 15,327 lbs. Therefore, as the one force is pulling upward and the other is pulling downward, the net upward force is equal to $15{,}327 - 7{,}997 = 7{,}330$ lbs. In fig. 260 the forces exerted in a horizontal direction, as indicated by the darts a and b, are the same as those exerted vertically in fig. 259, and therefore the net force exerted horizontally toward the left-hand side by the counterweight in this wheel, as indicated by the dart b, is again 7,330 lbs., which is just one-half the resistance due to the inertia of the reciprocating parts at the beginning of the stroke, as was shown in answer to Question 160. As the counterweights for the reciprocating parts on each side of the engine are supposed to be divided between two wheels, the net horizontal force of the two counterweights is just equal to the inertia of the reciprocating parts at the speeds on which these calculations are based. In fig. 261 the position of the crank-pin and the counterweight is reversed from that shown in fig. 259, and therefore there is a net centrifugal force of 7,330 lbs. exerted *upward*. In fig. 262 the position of the parts is in the reverse position to that shown in fig. 260, so that the difference of the centrifugal forces is exerted toward the right-hand side, and is then equal to the inertia of the reciprocating parts at the beginning of the forward stroke.

Question 421. *What effect do the counterweights have on the track?*

* The angularity of the connecting-rod causes the counterbalance to move somewhat slower than the piston while the crank-pins are in front of their axles or during the front half of their revolution, and faster during the back half, as was explained in answer to Question 142.

Answer. If the whole of the revolving and reciprocating parts are counterbalanced, the centrifugal force due to the counterweights of the reciprocating parts acts alternately upward and downward during each revolution of the wheels. Thus, if a driving-wheel 5 ft. in diameter is loaded with a weight of

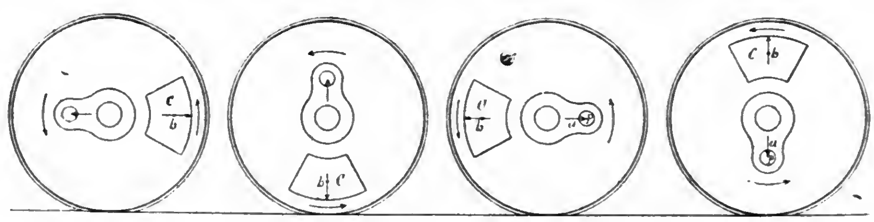


Fig. 262. Fig. 261. Fig. 260. Fig. 259.

14,000 lbs. at a speed of 50 miles under the conditions assumed above, its pressure downward, when in the position shown in fig. 259, would be:

$$14{,}000 - 7{,}330 = 6{,}670 \text{ lbs.},$$

and in the position shown in fig. 261,

$$14{,}000 + 7{,}330 = 21{,}330 \text{ lbs.}$$

At the dead points shown in figs. 260 and 262, the centrifugal forces act horizontally, and therefore have no influences either upward or downward. In moving from the position shown in fig. 259 to that shown in fig. 260, the upward pressure due to the centrifugal force gradually diminishes, and when the crank reaches the dead point this force is exerted horizontally, and produces no upward or downward pressure. In passing from the dead point to the position shown in fig. 261, the centrifugal force gradually increases in a downward direction until it reaches the position shown in fig. 261, and it then begins to diminish until it reaches the other dead point shown in fig. 262. It should be understood that the centrifugal force always acts radially, and that when the crank is in any position between those represented in figs. 259, 260, 261, and 262, the centrifugal force acts both horizontally and vertically, as was explained in answer to Question 159.

Owing to the vertical disturbing effects of the counterweights when the whole of the weight of the reciprocating parts is balanced, some engineers prefer to balance only a third, half, two-thirds, or some other fraction of the weight of the reciprocating parts of locomotives. In this way the vertical disturbance due to the inequality of the counterweights is diminished, but a horizontal disturbance is created; but neither are then as great as one of them would be if either the whole or none of the weight of the reciprocating parts was balanced.

(TO BE CONTINUED.)

Manufactures.

Mineral Products of the United States.

FROM advance proofs of Mineral Resources of the United States for 1887, furnished us by Mr. David T. Day, Chief of the Division of Mining Statistics and Technology of the United States Geological Survey, we obtain the following summary of the values of the metallic and non-metallic mineral substances produced in the United States during the calendar year 1887:

Metals	$250,419,283
Non-metallic mineral substances	281,637,062
	$532,056,345
Estimated value of mineral products unspecified	6,000,000
Grand total	$538,056,345

From the detailed statements given, we take the following paragraphs:

"*Iron.*—The principal statistics for 1887 were: Domestic iron ore consumed, about 11,300,000 long tons; value at mines, $33,900,000. This is an increase over 1886 of 1,300,000 tons in quantity and $5,900,000 in value. Imported iron ore consumed, 1,194,301 long tons; total iron ore consumed in 1887, about 12,494,301 long tons, or 1,454,868 tons more than in 1886. Pig iron made, 6,417,148 long tons; value at furnace, $121,925,800. This is an increase over 1886 of 733,819 tons in quantity and $26,730,040 in value. Steel of all kinds produced, 3,339,071 long tons, an increase of 776,569 tons over 1886; value at works, $103,811,000. Total spot value of all iron and steel in the first stage of manufacture, excluding all duplications, $171,103,000, an increase of $28,603,000, as compared with 1886. Limestone, used as flux in the manufacture of pig iron in 1887, about 5,377,000 long tons; value at quarry, about $3,226,200.

"*Copper.*—Total production, 184,670,524 lbs., of which 3,750,000 lbs. were made from imported pyrites. The total value was $21,052,440, at an average of 11.4 cents per lb. The estimated total consumption of copper in the United States increased by about 14 per cent.

"*Coal.*—The total production of all kinds of commercial coal in 1887 was 123,965,255 short tons (increase over 1886, 16,283,046 tons), valued at the mines at $173,530,996 (increase, $26,418,241). This may be divided into Pennsylvania anthracite, 39 506,255 short tons (increase, 2,809,780 short tons), or 35,273,442 long tons (increase, 2,508,732 long tons), valued at $79,365,244 (increase, $7,807,118); all other coals, including bituminous, brown coal, lignite, small lots of anthracite produced in Colorado and Arkansas, and 6,000 tons of graphitic coal mined in Rhode Island, amounting in the aggregate to 84,459,000 short tons (increase, 13,473,266 tons), valued at $94,165,752 (increase, $18,611,123).

"The colliery consumption at the individual mines varies from nothing to 8 per cent. of the total output of the mines, being greatest at special Pennsylvania anthracite mines and lowest at those bituminous mines where the coal-bed lies nearly horizontal and where no steam power or ventilating furnaces are used. The averages for the different States vary from 2.1 to 6½ per cent., the minimum average being in the Pennsylvania bituminous and the maximum average being in the Pennsylvania anthracite region.

"The total output of the mines, including colliery consumption, was: Pennsylvania anthracite, 37,578,747 long tons (increase over 1886, 2,725,670 long tons), or 42,088,197 short tons (increase, 3,052,751 short tons); all other coals, 87,837,360 short tons (increase, 14,129,403 tons), making the total output of all coals from mines in the United States, exclusive of slack coal thrown on the dumps, 129,925,557 short tons (increase, 17,182,154 tons), valued as follows: Anthracite, $84,552,181 (increase, $8,433,061); bituminous, $97,939,656 (increase, $19,458,600); total value, $182,491,837 (increase, $27,891, 661). The above figures show a notable increase in 1887 over 1886 in the aggregate output and value of both anthracite and bituminous coal.

"*Coke.*—The total production of coke in the United States for the year 1887 was 7,857,487 short tons, valued at $15,723,574. This is the greatest product ever reached in the United States, being 1,022,419 tons greater than in 1886.

"*Petroleum.*—Total production, 28,249,543 barrels of 42 gallons each. The total value, at an average of 60 cents, was $16,949,726. The increase over 1886 was very slight, only 139 428 barrels. There was a decrease of 11¼ cents per barrel in the average price.

"*Natural gas.*—The production of natural gas in the United States in 1887 was equivalent to 9,055,000 short tons of coal displaced. This, at an average value of $1.50 a ton, would make the value of the coal displaced by natural gas (which is the measure of the value of the gas), $13,582,500. In 1886 the corresponding quantity was 6,353,000 tons, worth $9,847,150.

"*Totals.*—The tabular statement shows an aggregate value of $538,056,345 for the year. This is the largest total ever reached by the mineral industries of any country. It is nearly $73,000,000 more than the product of the United States in 1886 and considerably more than $100,000,000 in excess of the year 1885. Of many items which have contributed to this result, it may be noted that all the metals increased in quantity except gold and the minor metal, nickel, and nearly all increased in price. The significance of this is seen in the increase in production of the fuels necessary for reducing these metals and preparing them for use. All of these fuels, including natural gas, show a marked increase. The increased value of building stone is principally due to a more careful canvass of this industry than has been possible in previous years. It is not probable that the great total recorded for 1887 will be equaled in the present year, 1888."

Cars.

THE Ensign Manufacturing Company at Huntington, W. Va., has recently closed a contract to furnish the Baltimore & Ohio Railroad Company with 2,500 car wheels per month.

THE Elliot Car Works at Gadsden, Ala., are building 300 more cars for the Alabama Great Southern road.

THE Southern Car Works at Knoxville, Tenn., are building 300 coal cars for the East Tennessee, Virginia & Georgia Railroad.

THE new South Baltimore Car Works have taken a contract for building 500 box cars for the Richmond & Danville road ; these cars are to be furnished with the Wagner door.

THE United States Rolling Stock Company is working steadily on the enlargement of its new car works at Anniston, Ala., the machine shops and the main building being now completed. Three new steam-hammers are being erected in the smith-shop, and work has been begun on a wood-working shop.

THE Centropolis Car & Machine Works is the name of a corporation which purposes building extensive car shops at Centropolis, a suburb of Kansas City, Mo. The works will cover 10 acres of land which has been bought for the purpose, and very extensive buildings have been begun. The new shops will build not only freight cars, but street and passenger cars.

Locomotives.

THE Rogers Locomotive Works, Paterson, N. J., have among other contracts an order for 30 locomotives for the St. Paul, Minneapolis & Manitoba Railroad.

THE Cooke Locomotive Works, Paterson, N. J., have recently taken a contract for 25 freight engines for the Chicago, St. Paul & Kansas City road.

THE Schenectady Locomotive Works are building 26 locomotives for the Chicago, St. Paul, Minneapolis & Omaha Railroad.

THE Rhode Island Locomotive Works, in Providence, have contracts for the Chicago, St. Paul & Kansas City ; for the Western & Atlantic and for the Minneapolis, St. Paul & Sault St. Marie road.

THE Manchester Locomotive Works, Manchester, N. H., recently delivered to the New York, Providence & Boston Railroad two locomotives intended to run the fast passenger trains on that road. These engines burn soft coal, have boilers 54 in. diameter of barrel, with 206 tubes 2 in. diameter, that are intended to carry a working pressure of 175 lbs. The cylinders are 17 in. in diameter and 24 in. stroke, and the driving-wheels are 68 in. in diameter.

THE Baldwin Locomotive Works, in Philadelphia, recently delivered to the New York, New Haven & Hartford Railroad six very heavy locomotives, intended to run the fast passenger trains between New York and New Haven. The same works are building some consolidation engines for the New Jersey Central, and are filling an order for 50 locomotives for the Philadelphia & Reading road.

THE Dickson Manufacturing Company in Scranton, Pa., is building 16 engines for the Central Railroad of Georgia, and is also building several engines with the Wootten fire-box for the Delaware, Lackawanna & Western road.

Manufacturing Notes.

MESSRS. T. WILLIAM HARRIS & COMPANY, 44 Broadway, New York, have been awarded the contract for laying mains for fuel gas at Tacony. This is the beginning of a system intended to furnish the city of Philadelphia with fuel gas, generated on the Loomis system, which, it is claimed, furnishes a very cheap and economical fuel. The same firm has recently been retained as consulting engineers by the Harvard Woolen Mill Company, and are now arranging a plan for disposing of the waste and wash of the mill in a satisfactory and proper manner.

ONE of the Mills in the Elliptic Department of the A. French Spring Company, in Pittsburgh, was damaged by fire August 15, but there has been no delay in filling orders, as the company has a duplicate mill.

THE Union Bridge Company, New York, has the contract for several steel bridges which will be required in the work of depressing the tracks of the New York Central & Hudson River road in New York City north of the Harlem River.

THE Sheffler Bridge Works, in Pittsburgh, are now putting up a number of iron buildings for the Disston Saw Works in Philadelphia, to replace shops recently burned. They have also a number of other iron structures to build.

THE Columbia Iron Company, at Uniontown, Pa., has contracts for a large amount of structural iron work, including buildings in Philadelphia, Cleveland, and Washington.

THE Riter & Conley Company, in Pittsburgh, recently shipped to Memphis, Tenn., a steel water-tower, for the water works in that city. The tower is 160 ft. high, 26 ft. in diameter, and will be secured to the stone foundation by 20 in. I-beams.

THE Chester Rolling Mill Company, in Chester, Pa., has let a contract for building a new Bessemeer steel plant, with a capacity of 2,500 tons per week. This plant will be erected by J. P. Withrow & Company, of Pittsburgh, Pa.

THE Westinghouse Air Brake Company has awarded the contract for the foundation work of its new works at Wilmerding, on the Pennsylvania Railroad, near Pittsburgh, and the contractors will soon begin work. Among the structures to be built are the machine-shop, which is to be 500×250 ft.; the foundry, 500×300 ft. ; the boiler-house, 160×80 ft., and the blacksmith-shop, 250×150 ft. It is estimated that the cost of the plant will reach nearly $1,000,000. A town is to be laid out.

Marine Engineering.

A LARGE steamer was launched from Reybolt & Walter's yard at Sheboygan, Wis., on July 28. It is a wooden vessel 276 ft. keel, 299 ft. over all, 40 ft. beam, and 26 ft. molded depth. The engine is a triple expansion, with cylinders 20, 32, and 54 in. diameter, and 42 in. stroke. She is intended to carry grain, and will run from Milwaukee.

THE side-wheel steamboat *Puritan*, built for the Old Colony Steamboat Company, was launched July 25 from the yard of the Delaware River Iron Ship Building Company, at Chester, Pa. The *Puritan's* hull is all steel, and her dimensions are 404 ft. on the water line, 420 ft. long over all, 20½ ft. hold, 52 ft. beam, and 91 ft. breadth over guards. The hull is to be taken to New York, where the upper works will be put on and where the engine is to be built, and the boat will be ready to take her place in the line next season. The engine of the *Puritan*, which is built by the W. & A. Fletcher Company in New York, will be a compound beam engine, having a high-pressure cylinder 75 in. diameter and 9 ft. stroke and a low-pressure cylinder 111 in. diameter and 14 ft. stroke. She is somewhat larger than the *Pilgrim*, built for the same line a few years ago, and will differ from her in having a compound engine.

THE *Marine Journal* publishes the following list of American steamers which will answer the requirements of the Naval Reserve Bill in regard to speed :

Vessel.	Hailing Port.	Tonnage.	Speed.
Newport	New York	2,735	17.9
City of Augusta	Savannah	2,870	16.5
City of Puebla	San Francisco	2,624	16.5
Queen of the Pacific	Portland, Ore	2,728	16.5
Alameda	Philadelphia	3,158	16.5
Mariposa	San Francisco	3,158	16.5
State of California	San Francisco	2 266	16
Allianca	New York	2.985	16
Louisiana	New York	2,840	16
Ohio	Philadelphia	3,126	15.6
Saratoga	New York	2,426	15.4
City of Alexandria	New York	2,480	15.4
Nacoochee	Savannah	2,680	15.4
Chattahoochee	New York	2,676	15.4
Roanoke	New York	2,354	15.4
Excelsior	New York	3,264	15.4
Alamo	New York	2,943	15.4
Lampasas	New York	2,943	15.4
El Paso	New York	3,531	15.4
El Dorado	New York	3,531	15.4
H. F. Dimock	Boston	2,625	15.4
Herman Winter	Boston	2,625	15.4
Seminole	New York	2,557	15.4
El Monte	New York	3,531	15.4
San Pedro	New York	3,119	15.4
San Pablo	New York	4,064	15.4
Cherokee	New York	2,557	15
Santa Rosa	New York	2,417	15

The Navy Department has thus accredited 28 American steamers of from 2,400 to 4,000 tons with a sea speed of 15 knots or over, and from these vessels, should the Naval Reserve

Bill finally pass, will be made the selection of the ships which will be called into use as cruisers in case of emergency.

Steel and Steel Rail Production.

THE *Bulletin* of the American Iron & Steel Association gives the production of Bessemer steel and steel rails in the United States for the first half of 1888 as follows, in net tons :

	Bessemer.	Clapp-Griffiths.	Total.
Steel ingots	1,348,218	36,070	1,384,288
Steel rails	775,261	......	775,261

The totals for the last half of 1887 were 1,650,785 tons of ingots and 1,146,117 tons of rails ; showing a decrease of 18¼ per cent. in ingots and 32¼ per cent. in rails.

The *Bulletin* says : "These figures do not include a few thousand tons of Bessemer steel rails rolled in each period in iron rolling mills from purchased blooms. The production of Bessemer steel rails in the first half of 1888 was reduced much more than that of ingots, indicating an increased use of Bessemer steel thus far this year for miscellaneous purposes of nearly 100,000 gross tons over the last half of 1887."

Proceedings of Societies.

American Society of Civil Engineers.

THE Board of Direction of this Society invites professional papers and communications on subjects of engineering interest from all persons, whether members of this Society or not. These papers and communications will be accepted for publication in the *Transactions* of the Society, subject to the regular rules prescribed by the Society laws, which provide for a proper editorial supervision, and for the exclusion of old matter readily found elsewhere, of matter specially intended to advocate personal interests, of matter carelessly prepared or controverting established facts, and of matter purely speculative or foreign to the purposes of the Society. Discussion is also invited from all persons interested in the papers presented to the Society, such discussion to be, of course, subject to the same editorial rules.

The *Transactions* of the Society will be sent to any subscriber at the rate of $10 per year ; and to clubs of ten or more, when ordered through the Secretary of an engineering or technical society or club, who will be responsible for the payment, at 25 per cent. discount.

Engineers' Society of Western Pennsylvania.

AT the last meeting of the season, in Pittsburgh, June 19, B. Speer, R. B. Lean, C. H. Davis, A. C. Cunningham, E. H. Kenyon, A. F. Keating, Frank J. Kimball, William Bakewell, and A. L. Reineman were elected members.

Mr. W. E. Koch's paper on Open-Hearth Steel was discussed by Messrs. Stafford, Bailey, Reese, A. E. Hunt, Roberts, Rodd, Brashear, and Koch.

A communication from the Engineers' Club of Kansas City, asking co-operation in the effort to bring about Government inspection of bridges, was received, and, together with a request from the Western Society of Engineers, was referred to a special committee, consisting of A. E. Hunt, Thomas Rodd, Charles Davis, G. Lindenthal, and F. C. Osborn.

A resolution commending the establishment of a technical school in connection with the Western University of Pennsylvania was adopted.

The death of David A. Smith was announced, and a committee appointed to report at next meeting.

Engineers' Club of Cincinnati.

AT the regular meeting, July 11, there were 17 new members elected, making the total number 57.

Mr. J. Foster Crowell led a discussion on Skew Arches, maintaining that the difficulty and (when brick is largely used) the expense of skew construction are usually overestimated by engineers.

He described minutely a skew arch recently built by him near Oakley, O., to carry a double-track railway through the embankment of another railway. The angle of skew was 47½° ; span of arch, 28 ft. ; length, 80 ft., with 40 ft. wing walls at either end. The body of arch was of ordinary brick laid in spiral courses conforming to guide lines marked on the lagging, each course springing from a skew-back of cut stone. The faces of the arch were of stone, the beds of each stone being cut to helicoidal surfaces. No specially skilled stone-cutters were required. The structure cost the railroad but 5 per cent. more than the same amount of plain first-class masonry would have cost at contract price, while the saving in amount of masonry secured by the adoption of skew construction was 15 per cent.

As an interesting incident, Mr. Crowell mentioned that during the ten months occupied in constructing this arch beneath the Cincinnati, Washington & Baltimore Railroad, not one of the very numerous daily trains on that road was delayed.

Association of American Railway Accounting Officers.

THIS Association was fully organized at a meeting held in New York, July 25 and 26, when a constitution was adopted, and the following officers were elected : President, Marshall M. Kirkman, Chicago & Northwestern ; First Vice-President, Max Riebenack, Pennsylvania Railroad ; Second Vice-President, G. L. Lansing, Southern Pacific Company ; Secretary, C. G. Phillips, Chicago ; Executive Committee, J. P. Whitehead, Cushman Quarrier, S. M. Williams, D. A. Waterman, Stephen Little, S. B. Willey, and Chauncey Kelsey.

The object of the Association is to secure uniformity in accounts, prompt adjustment of claims, and, by mutual discussion, improved methods of accounting.

Addresses were delivered before the Association as follows—viz. :

Joint Through Freight Accounts, T. J. Hyman, Auditor and General Accountant Wisconsin Central Associated Lines.

The Accounting Department as a Factor in the Management of Railroads, S. M. Williams, Comptroller Central Railroad of New Jersey.

The Settlement at Junction Points of the Charges on Prepaid Shipments, Way-billed *via* Fast Freight Lines, and upon which Bills a Division of Revenue is Stated, J. P. Curry, Auditor New York, Chicago & St. Louis Railroad.

The Coupon Accounts of Railroads, M. Riebenack, Assistant Comptroller Pennsylvania Railroad.

The suggestions and recommendations contained in these suggestions were referred to the Executive Committee, and will at a future meeting come before the Association for definite action. In the mean time, the addresses will be printed in the report of the proceedings and circulated among all interested. More than 100 roads are already represented in the Association, and the Secretary will be pleased to receive applications for membership from those eligible.

Master Car and Locomotive Painters' Association.

THE nineteenth annual meeting of this Association will be held in Cleveland O., beginning on Wednesday, September 12, at 10 A.M. A general invitation is given to foremen car and locomotive painters throughout the United States and Canada to be present at the convention. The programme includes papers and discussions on a number of subjects of practical importance.

Master Mechanics' Association.

SECRETARY ANGUS SINCLAIR has issued the following list of the committees appointed by President Setchel to carry on the work of investigation and other business during the ensuing year :

1. *Purification, or Softening, of Feed Water :* Herbert Hackney, John Player, W. T. Small.
2. *Tires. Advantage, or otherwise, of Using Thick Tires :* J. W. Stokes, C. E. Smart, Henry Schlacks.
3. *Exhaust Pipes and Nozzles ; Best Form and Size in Proportion to Cylinder :* C. F. Thomas, A. W. Gibbs, George D. Harris.

4. *Driving and Engine Truck Boxes; Best Form and Material, including Journal-bearing and Method of Fastening same in Box:* William Buchanan, John W. Cloud, J. M. Boon.

5. *Boiler Covering; Best Method and Material to Prevent Radiation of Heat:* G. W. Stevens, John Mackenzie, T. B. Twombly.

6. *Driver Brakes; Best Manner of Applying, including Best Form and Material for Driving Brake-shoes:* Charles Blackwell, H. D. Gordon, W. H. Thomas.

7. *Best Proportion of Grate and Flue Area:* J. Davis Barnett, G. W. Ettenger, Philip Wallis.

8. *Foundation Ring for Boiler-leg; Best Form, and Advisability of Double Riveting:* J. N. Lauder, W. J. Robertson, Harry Tandy.

9. *Water Space Surrounding Fire-box; is it usually Large enough for Free Circulation?* John Hickey, J. N. Barr, R. W. Bushnell.

10. *Magnetic Influence of Iron and Steel in Locomotives on the Watches of Engine-runners:* T. W. Gentry, James Meehan, Harvey Middleton.

Paper to be read by Coleman Sellers, Associate Member.

Committees to prepare Obituaries of Deceased Members: Of Charles T. Parry: E. H. Williams, Isaac Dripps, H. D. Garrett. *Of W. H. Morrow:* W. L. Austin, L. M. Ames, L. B. Paxson. *Of Robert Curtis:* E. B. Wall, W. W. Reynolds, Leroy Kells. *Of J. O. D. Lilly:* Reuben Wells, William Swanston, John McKenna.

Committees are urged to begin the work assigned them as early as possible, in order that valuable reports may be prepared in good season for the next Convention.

American Institute of Mining Engineers.

The following circular has been issued by the Secretary, Professor R. W. Raymond, from his office, No. 13 Burling Slip, New York:

"I. The Fifty-second Meeting of the Institute will be held at Buffalo, N. Y., beginning on Tuesday evening, October 2, 1888. Further particulars will be given in a later circular. Members proposing to present papers at this meeting should notify the Secretary of the Institute as early as possible, stating the nature of the proposed papers."

New England Roadmasters' Association.

The sixth annual meeting was held in Boston, August 15 and 16. On the first day the proceedings opened with an address from the retiring President, Mr. J. S. Lane, and the usual routine business was disposed of. The following officers were elected for the ensuing year: President, J. R. Patch; Vice-President, G. W. Bishop; Chaplain, E. Newcomb; Secretary, W. F. Ellis; Treasurer, George Nevens; Executive Committee, F. C. Clark, J. W. Shanks, and L. H. Perkins.

Reports were presented by different committees on Highway Crossings and the Best Method of Making Them; on Steel Rails and Rail Joints; on Ballast; on Ties and on Hand Cars. These reports were thoroughly discussed by the members present.

The meeting closed by an excursion trip down the harbor. The attendance was not large, the time chosen for the meeting being, unfortunately, in the busy season for members.

American Association for the Advancement of Science.

The thirty-seventh annual meeting began in Cleveland, O., August 15. The new President, Major J. W. Powell, took the chair and made a brief address. Dr. Julius Pohlman was chosen General Secretary. The annual report showed 113 new members; 137 papers had been filed for reading and discussion at this meeting.

In the afternoon the Association divided into eight sections for the reading and discussion of papers, a number of which were disposed of, the most important being that of Professor George H. Cook, of New Jersey, on the International Geological Congress.

In the evening there was a short session, which was followed by a general reception to the members.

The meeting continued through the week, a large number of papers being read in the different sections. Two general meetings were also held.

OBITUARY.

Colonel B. W. Frobel, who died in Monticello, Ga., July 22, aged 56 years, was born in Alexandria, Va., and graduated from West Point, serving for some time in the Army. During the War he was in the Confederate service, and since its close has been actively engaged as a civil engineer. For two years past he had been Chief Engineer of the Macon & Covington Railroad.

James T. Clark, who died in Milwaukee, Wis., July 21, aged 56 years, was for nearly 20 years on the Chicago, Burlington & Quincy in various subordinate positions. In 1873 he went to the Union Pacific as Division Superintendent, and four years later was appointed General Superintendent of the road. In 1882 he was appointed General Superintendent of the Chicago, Milwaukee & St. Paul, and held that position until his death.

P. D. Cooper, who died in Elkhart, Ind., July 25, aged 54 years, was for many years employed on the Lake Shore road, rising gradually from the position of station agent to be Assistant General Superintendent. In 1873 he was appointed General Superintendent, and later General Manager of the New York, Pennsylvania & Ohio Railroad, but retired in 1882 on account of ill-health, and has not since been engaged in active work.

General Williams C. Wickham, who died in Richmond, Va., July 23, aged 67 years, was for many years engaged on the Chesapeake & Ohio Railroad. As President at first he actively pushed forward the work of building the road, and when the company was reorganized he had charge of its operation as Vice-President and General Manager. For some months past he had been Receiver. General Wickham was in the Confederate cavalry service during the War, and served several terms in the Virginia Legislature.

Colonel James N. Smith, who died in Litchfield, Conn., July 31, was for a number of years a member of the well-known contracting firm of Smith & Ripley, who built the Fourth Avenue Improvement on the Harlem Railroad in New York, and also had large contracts on the Union Pacific, the New York, Chicago & St. Louis, and many other roads. For several years past Colonel Smith has lived in Brooklyn, but has spent most of his time in the South, where he was largely interested in building railroads in Georgia and Florida.

Jacob French Sharp, who died in Wilmington, Del., August 2, aged 73, was born in Hunterdon County, N. J. In early life he was a carpenter and afterward a bridge-builder, and built a large number of wooden bridges, including several important railroad structures. About 1840 he settled in Wilmington, and engaged in the business of building cars, founding with Mr. Jackson the works that have since become so widely known under the name of the Jackson & Sharp Company. Mr. Sharp retired from active business some 12 or 14 years ago, although still retaining an interest in the company.

Charles Crocker, who died in Monterey, Cal., August 14, aged 66 years, was born in Troy, N. Y., and went to California in 1849, where he engaged in business in Sacramento. In 1860 he joined with C. P. Huntington, Mark Hopkins, and Leland Stanford in building the Central Pacific Railroad. In 1862 he was made General Superintendent of the road and later Vice-President. In 1871 he was chosen President of the Southern Pacific Company, and he was the chief agent later in consolidating the property of the two companies. For some years past Mr. Crocker had not taken an active part in the management of his roads, but spent much of his time in New York. His death was the result of injuries received from being thrown out of a carriage over two years ago. Mr. Crocker leaves a very large fortune.

Colonel James Stevenson, who died in New York, July 20, aged 48 years, was for many years connected with the United States Geological Survey as Ethnologist. At an early age he showed a strong taste for ethnology, and before his fifteenth year went beyond the frontier and studied the characteristics of

several Indian tribes. In his sixteenth year he became engaged in the Government geological work, then being carried on under Professor Hayden, the head of the Geological Survey. His researches were interrupted by the War. Immediately thereafter he began a series of explorations. When Major J. W. Powell was placed at the head of the Geological Survey, he appointed Colonel Stevenson his Executive Officer. During recent years, however, Colonel Stevenson, at his own request, has been detailed on special ethnological research in connection with the Smithsonian Institution.

PROFESSOR HENRY CARVILL LEWIS, who died in Manchester, England, July 31, aged 35 years, was born in Philadelphia, and was graduated at the University of Pennsylvania in 1873; in 1879 he joined the State Geological Survey as a volunteer, and first investigated the surface geology of Southern Pennsylvania, after which he studied the glacial phenomena of the northern part of the State, and traced the great terminal moraine from New Jersey to the Ohio frontier. He furnished numerous papers on the geology and mineralogy of Pennsylvania to the *Proceedings* of the Philadelphia Academy of Natural Sciences. He was elected Professor of Mineralogy in the Academy of Natural Sciences in 1880, and to the chair of geology in Harvard College in 1883. These positions he held at the time of his death. Since 1885 he had been engaged in geological studies in Europe, working at microscopic petrology in the University of Heidelberg, and had completed a map of the separate ancient glaciers and ice-sheets of England, Wales, and Ireland. Professor Lewis was a member of a number of scientific societies in the United States and Europe, and contributed to their *Proceedings* and to other scientific periodicals, including the *American Naturalist*, of the mineralogical department of which he was for some time editor.

LIEUTENANT-COLONEL WALTER MCFARLAND, United States Engineer, who died in New London, Conn., July 22, aged 52 years, was born in New Jersey, and was appointed from New York to the West Point Military Academy, where he was graduated in 1860, ranking first in his class. He was brevetted Second Lieutenant in the Corps of Engineers in July of that year, and was detailed as Assistant Engineer in the construction of the defenses of the approaches to New Orleans. Afterward he was engaged on the fortifications at Key West, Fla., and from April 16, 1861, till the following September as Assistant Engineer in the defense of Fort Pickens, Fla. With the rank of First Lieutenant he then took part in the naval expedition for constructing the defenses at the heads of the passes of the Mississippi River. Afterward he superintended engineering work at Key West and Fort Jefferson, Fla., and was Assistant Engineer in military operations near Charleston, S. C. He was made a Captain in the Engineer Corps, 1863, and till 1865 he had charge of the defenses at Mobile, as Chief Engineer of the Sixteenth Army Corps. During a part of 1865 he served as Assistant Adjutant-General of the Thirteenth Army Corps. In March, 1867, he was promoted to the rank of Major, and since March, 1884, he had been Lieutenant-Colonel of Engineers. Since the retirement of General John Newton, Colonel McFarland has been in charge of the improvements at Hell Gate. He bore a high reputation as a military engineer.

PERSONALS.

G. N. MILLER, of St. Paul, Minn., has been appointed Superintendent of Sewers at Helena, Mont.

W. D. MINTON has been appointed Master Car-Builder of the Texas & Pacific Railroad.

M. T. CARSON has been appointed Superintendent of Motive Power of the Mobile & Ohio Railroad.

ROBINS FLEMING, C.E., has resigned the position of Instructor of Civil Engineering in Lafayette College, Easton, Pa.

J. B. MOLL has been appointed General Roadmaster of the Chicago, Milwaukee & St. Paul Railway, with office in Milwaukee.

T. A. PHILLIPS has been appointed General Superintendent of Transportation of the East Tennessee, Virginia & Georgia Railroad.

J. F. HINCKLEY has resigned his position as Chief Engineer of the St. Louis, Arkansas & Texas road, and will take a trip to Europe.

W. G. CLARK has been appointed General Superintendent of the Northern Division of the Mexican National Railroad, with office at Laredo, Tex.

A. J. EARLING is now General Superintendent of the Chicago, Milwaukee & St. Paul Railway, succeeding the late J. T. Clark. Mr. Earling has been connected with the road for more than 20 years.

CHARLES MACDONALD, of the Union Bridge Company, recently returned from his trip to Australia, where he has been superintending the work of putting down the foundations for the great Hawkesbury Bridge.

W. C. VAN HORNE, who succeeds SIR GEORGE STEPHEN as President of the Canadian Pacific Company, has been Vice-President for some time, and had previously served as General Superintendent of the Chicago, Milwaukee & St. Paul, the Chicago & Alton, and several other roads.

FRANK M. WILDER, recently General Manager of the Safety Car Heating & Lighting Company of New York, has accepted the position of Assistant to the President of the United States Rolling Stock Company, with headquarters at New York. He will have general supervision of all the shops of the company.

J. R. SHALER has resigned his position as General Superintendent of the New York, Pennsylvania & Ohio road, and the office has been abolished. Mr. Shaler has been General Superintendent for two years, and was previously Superintendent of the Eastern Division. The resignation took effect August 1.

WILLIAM R. BILLINGS, formerly Superintendent of the Taunton Water-Works, and more recently connected with the Chapman Valve Manufacturing Company, of Boston, has been chosen Agent and Treasurer of the Taunton Locomotive Manufacturing Company, of Taunton, Mass., and assumed the duties of his new office August 1.

COLONEL GEORGE W. PERKINS, who recently celebrated his 100th birthday at Norwich, Conn., has been for 53 years—from its first organization—an officer of the Norwich & Worcester Railroad Company. He has always been an active man, and is still able to attend to business, in spite of his great age. Colonel Perkins received many presents and other attentions on his birthday.

THE following promotions in the Engineer Corps have been made, consequent on the appointment of Colonel Casey to be Chief of Engineers: LIEUTENANT-COLONEL ORLANDO M. POE to be Colonel; MAJOR SAMUEL M. MANSFIELD and MAJOR WILLIAM R. KING to be Lieutenant-Colonels; CAPTAIN JAMES B. QUINN to be Major; FIRST LIEUTENANT FREDERICK V. ABBOTT to be Captain; SECOND LIEUTENANT WILLIAM E. CRAIGHILL to be First Lieutenant.

J. H. SETCHEL resigned his position as Superintendent of the Brooks Locomotive Works at Dunkirk, N. Y., on August 1. He will take a well-earned rest before entering upon any new work. In a circular stating Mr. Setchel's resignation, the Brooks Locomotive Works say:

"In making this announcement the Brooks Locomotive works wish to express their high appreciation of the mechanical ability and faithful services rendered by Mr. Setchel while in charge of the construction departments of their works."

THE venerable CAPTAIN JOHN ERICSSON passed his eighty-fifth birthday at his house in Beach Street, New York, on July 31. The day was spent in his usual occupations, but in the morning he received a call from Consul-General Bors, as representative of the Swedish Government in New York, and in the evening about 400 members of the United Scandinavian Singing Societies serenaded him, singing Swedish national and other songs. Captain Ericsson is in excellent health, and is still a steady and persistent worker, but lives very quietly.

THE Croton Aqueduct Commission, appointed by the Mayor of New York under the new law, consists of GENERAL JAMES C. DUANE, FRANCIS M. SCOTT, JOHN J. TUCKER, and WALTER HOWE. General Duane has just been retired from the office of Chief of Engineers, U.S.A., having reached the limit of age for active service prescribed by law; he is, however, still an active man, and is an engineer of high reputation. He had charge of the building of the Washington Aqueduct some years ago. Mr. Scott is a lawyer, and is very familiar with city business, having been Assistant Corporation Counsel. Mr. Tucker is a well-known builder, who has erected some of the largest buildings in the city, and Mr. Howe is a citizen of wide acquaintance and excellent reputation, both for his integrity and his public spirit. It would be a very difficult matter to pick out a better commission.

NOTES AND NEWS.

Oil Tank Steamers in England.—Another petroleum tank steamer was launched recently from the shipyard of Messrs. Armstrong, Mitchell & Company. The new vessel is called the *Oevelgonne*, and will carry in her tanks 3,800 tons, or over 1,000,000 gallons of petroleum each trip. Two powerful Worthington pumps and a complete installation of piping will enable the oil to be pumped in or out of any compartment, or from one to the other. Under the old system of transporting the oil in barrels many days would be needed to barrel and stow a million gallons of oil; whereas in these new tank steamers it is simply a question of a few hours, requiring practically no labor whatever.

Baltimore & Ohio Employés' Relief Association.—The June statement of this Association shows the following payments for the month:

	Number.	Amount.
Accidental deaths	4	$4,000
Accidental injuries	300	4,054
Surgical expenses	225	1,089
Natural deaths	9	4,802
Natural sickness	500	8,111
Total	1,038	$22,056

The total number of payments made since the Association was organized in 1880 has been 78,079, and the total amount has been $1,768,924.

Coal Industry of Russia.—A report from the British Consul at Taganrog on the coal industry of Southern Russia has just been laid before Parliament. The annual output at present exceeds 1,600,000 tons, of which about 1,300,000 tons are carried by railroad, but it is calculated that nearly 3,000,000 tons will be available for transport during the present year, besides the quantity consumed in the neighborhood of the mines. A long list is given of the quantities sent away by the various railroads and consumed in different undertakings. The increased sale of Donetz coal is principally due to the duty on foreign coal, the prices of which in 1887 were unremunerative, owing to capricious railroad rates, absence of shipping facilities, and the great expense of landing coal at such ports as Taganrog and Mariapol. Mr. Wagstaff thinks English colliery owners have no need to fear their Russian rivals in foreign markets.

A Railroad to Soukhum-Kale.—The Russian Government contemplates constructing a railroad shortly to Soukhum-Kale. This port lies in somewhat an isolated position, and it was in order to remove this that a military road was recently constructed to it across the Caucasus ridge from Ekaterinadar. It is now proposed to run a branch line to the port from the Transcaucasian Railroad via Novo-Senaki. This would be 79 miles long, and could be accomplished with very few engineering difficulties. The climate of Soukhum-Kale is so good that the place is used as a sanitary station for the Caucasian army. The construction of the line would give a new impulse to the port by rendering it an outport for Transcaucasian produce. It would also open up much of the country to colonization, and the authorities are now disposed to take this question vigorously in hand, in connection with the proposed railroad.

Developing the Coal Mines in the Argentine Republic.—The Legislative Assembly of the Argentine Republic, in order to encourage the development of the coal-mining industry, has approved a proposal made by a private company by which the Government guarantees to the company undertaking to work the coal mines of Rioja an interest of 5 per cent. on the capital invested for 15 years; the company to invest a capital of $2,000,000, the guarantee of the Government to begin from the day that the railway connection is established or from the day when actual work begins in the mines. If the work at the mines is stopped for four months, the Government guarantee is withdrawn. If the company's profit reaches 10 per cent. of the capital invested, all the surplus profit is to be paid to the Government until all the guarantee disbursement made by the Government has been paid back, together with 5 per cent. yearly interest on it.

A Railroad in Persia.—According to the Moscow papers, the first line of railroad in Persia was opened about June 20. It has been constructed by a Belgian company, and extends from Teheran to Shag-AbdulA-zima, a distance of about 10 miles.

The construction of this line was surrounded by enormous difficulties, arising chiefly from the transport of material into Persia. Each mile cost nearly $36,000, and the whole cost more than $400,000. The larger portion of the material was brought through the Caucasus and Russia from Belgium, and the duty paid amounted to $40,000. It may be taken for granted that this short section of railroad cannot possibly pay the company, but the question of securing concessions for the construction of the entire line from the Persian Gulf to the Caspian Sea is conditioned on the success of this portion of the railroad. The object of beginning construction at Teheran instead of the Caspian was doubtless to enable the Shah to see the road, in the expectation that he would be pleased with his new toy.

New Railroad Bridge in Sweden.—The highest bridge in Sweden is rapidly approaching completion. It is being built by the Motala Engineering Company, for the Swedish State Railroads, across the Angerman River. It was to have been ready by August 1, but unforeseen circumstances will delay its completion. The bridge has five arches and a total length of 825 ft., the central arch, which at low water spans the whole of the river, being 225 ft. long. The bridge is supported by four iron piers, of which those on each side of the river are 100 ft. high and rest on huge granite foundations. In these granite pillars are holes for placing dynamite, in case it should be necessary during a war to blow up the bridge. The stone work is already completed, and also the extensive scaffolding, which, however, does not comprise the distance between the two central piers, as the bridge will have to be built in a similar manner to that practised at the Forth Bridge. The bridge has been constructed by Mr. O. Nystrons of the Motala Engineering Company, and the total cost is likely to amount to about $117,000.

Railroads in Sumatra.—Under the direction of the Dutch Government surveys have been made for a railroad to run from the Port of Padang in Sumatra to Ombilien, where there are known to exist extensive deposits of coal of very good quality. These have not been developed to any extent owing to lack of transportation. The distance between the two points is 78 kilos. in a straight line, but between them is a lofty mountain chain which must be surmounted by the railroad, and which will render necessary a line about 145 kilos. in length. After studying a number of proposed routes, the plan adopted by the engineers is to build a road with moderate grades over the plain at the foot of the mountain to a point 56 kilos. from Padang. From that point there will be a line of 26 kilos. in length over the mountain with grades varying from 4 to 7 per cent., and on this section it is proposed to use the Riggenbach rack-rail system. After passing the mountain another section 63 kilos. in length will reach the coal basin; this will have only moderate grades, and will be worked by ordinary locomotives. The plans have been submitted to the Government and approved, and the construction will very soon be begun.

Railroads in Ceylon.—There are 182½ miles of railroad in operation in Ceylon, and all are of 5 ft. 6-in. gauge—viz., Colombo to Kandy, 74½ miles; Peradeniya to Nanuoya, 58¾ miles; Colombo to Kalutara, 27¾ miles; Wharf and Breakwater branch, 4½ miles; Peradeniya to Matale, 17½ miles; total, 182½ miles.

The total profit earned on all the railroad lines at present in operation is about 3 per cent. on the invested capital, which, it is to be feared, is not likely to be appreciably increased so long as the present expensive system is adhered to. Briefly stated, the railroads of this country have proved a positive incubus to the island; excepting, perhaps, the line to Kandy, beyond which place the system never ought to have been extended.

The total cost of the 182½ miles in operation was, exclusive of interest, $16,166,132 in gold.

At present there is no railroad construction in progress, but the following lines have been surveyed—viz.: Kandy to Badulla, 3-ft. 6-in. gauge, 62½ miles, cost not estimated; Nanuoya to Haputale, 5-ft. 6-in. gauge, 26 miles, $3,013,000; Mahara to Chilaw, 5-ft. 6-in. gauge, 40 miles, $1,150 000; Mahara to Chilaw, 3-ft. 3⅜-in. gauge, 40 miles, including to Colombo, $1 200,000; Kalutara to Bentota, 5-ft. 6 in. gauge, 9 miles, no published particulars; Mahara to Jaffna, 183 miles, no published particulars; Mattakuliya to Colombo (tramway), 4⅛ miles, $271,000.

Proposed Railroads in Asia Minor.—The principal conditions promulgated by the Imperial Administration of Public Works, upon which concessions will be granted for the proposed railroads in Asia Minor, are given below:

The duration of the concession shall be 99 years.

The grantees will be authorized to form a joint company, provided that the company shall be Ottoman and subject to the jurisdiction of Ottoman courts in all its operations.

All public lands necessary for the construction of the road will be ceded gratuitously, land and property belonging to private owners to be expropriated by the grantees or the company.

All supplies necessary for the first establishment of the line shall be exempt from the payment of customs duties.

The contract for its concession and the bonds and obligations of the company shall be exempt from stamp duties.

For the purpose of securing the necessary sums to make up the amount of 15,000 francs gross receipts per kilometer of road built and operated, the following plan will be adopted :

Securities are to be given by the tithe-farmers for the full value of the tithes, and are to be registered in the name of the treasuries of the administration of the public debt in the said several sandjaks. The full amount of the value of said tithes to be at once deposited in said treasuries, and the amounts which the Imperial Government promises and engages itself to pay to make up the amount of gross annual receipts, as above indicated, to be levied on the said value of the tithes, the balance to be remitted to the treasury.

The line now in operation between Haidar-Pacha and Ismidt (95 kilometers), of which the actual receipts are about 10,000 francs, and the works already constructed beyond Ismidt, shall be ceded to the company upon payment of an adequate amount.

Russian Petroleum Trade.—The report of Mr. James C. Chambers, United States Consular Agent at Batoum, Russia, to the State Department, gives elaborate statistics of the shipments of petroleum for two years past, which are summed up as follows, the figures given being for gallons :

	1887.	1886.
From Batoum (Black Sea):		
To Russian points	9,764,050	13,523,330
To foreign countries	67,969,935	54,236,320
Total	77,733,985	67,759,650
From Baku (Caspian Sea):		
To Russian points	310,292,715	265,677,895
To foreign countries	1,789,930	1,305,117
Total	312,082,645	266,983,012
Total of all shipments	389,816,630	334,742,662

The exports from Baku last year were all to Persia ; of those from Batoum about 80 per cent. were to European countries, including Turkey ; 13½ per cent. to Asiatic countries, and 6½ per cent. to African points.

Mr. Chambers says : "The prospects of the Batoum petroleum exporters for 1888 were never brighter, with greatly increased railroad transportation, declining prices at Baku, a steady downward tendency in the value of Russian paper money, and high and advancing prices in the markets of the world. If they do not reap a rich harvest this year, they will have lost a golden opportunity, such as is rarely seen in any business. It is expected here that the Batoum exports this year will be over 150,000,000 gallons, almost double those of 1887, but I do not believe it is possible for them to exceed 120,000,000 gallons. A very good beginning has been made, however, as the January shipments were over 10,000,000 gallons, and the steamer charters for cases January, February, and March, loading for India alone, are nearly 6,000,000 gallons."

The New Brooklyn Dry Dock.—One of the works of greatest magnitude at present under way at the Brooklyn Navy Yard is the digging of the new dry dock.

This dock is one of two contracted for by J. E. Simpson & Company, of New York. The other is being built at the Norfolk Navy Yard, and both together were to be finished for somewhat less than $1,100,000, with a limit of two years in which to complete the work. The material used is spruce, oak, and yellow pine, which is brought from Georgia and the Carolinas, and of which almost the entire dock is to be built, the bottom being concrete over the head of piles driven in as close together as they can be forced.

The length of the Brooklyn dock is 500 ft., extreme width 130 ft. and 4 in., and the depth 32 ft. 8 in.

The steam digger at first employed was found to be not suited to the soil, and the machine was so undermined by its own efforts as to render it practically valueless. A digger of the "clam-shell" type is now employed, and the work has progressed fairly well, although much more slowly than was expected at the start. The fine, sandy soil found at the depth at present reached, as well as the numberless springs of fresh water struck in almost every part of the dock, render digging very slow and unsatisfactory. Large centrifugal pumps are constantly at work freeing the dock of this water, and even then the men at work are frequently up to their knees in the soft, slimy ooze.

To prevent the water filtering in from the Wallabout at a point which will eventually be the mouth of the dock, double-sheet piling is driven, and the intermediate space is filled in with clay. This renders it fairly water-tight, and aids greatly in expediting the work. The caisson, as the boat-shaped gate is called, which closes up the mouth of the dock when finished, is to be made of steel, and has been contracted for by Messrs. Bigelow & Co., of Newburg, N. Y., and is of a pattern that has frequently proved extremely efficacious.

The Centennial of the Marine Engine.—At the recent meeting of the Institution of Naval Architects held in Glasgow, Professor H. Dyer read a paper on The First Century of the Marine Engine," in which he called attention to the fact that the present year is the hundredth anniversary of steam navigation, Mr. Miller having made his first experiment in Dalswinton water in 1788. The following abstract of the paper is taken from *Engineering :*

"The paper commences with the Dalswinton experiment of the three pioneers, Miller, Taylor, and Symington, and then goes on to speak of the *Charlotte Dundas*, designed by Symington in 1801, and tried on the Forth & Clyde Canal in 1802 ; this being described as the first practical steamboat. The attempts of John Fitch, of Connecticut, extending from 1787 to 1798, are touched upon, but all his attempts are described as unfortunate. Robert Fulton's steamer, tried on the Seine in 1803, is mentioned ; his further work in America being also chronicled. John Stevens, of Hoboken, and his son, Robert L. Stevens, also find a place in the record. Henry Bell, of Helensburgh, with the *Comet*, brings the history back to the Clyde District, and John Wood's *Elizabeth*, built for Thomson, is next dealt with. In a foot-note the Author refers to the contribution of Mr. Miller to the *Transactions* of the Institution of Engineers & Shipbuilders of Scotland, vol. xxiv., page 49 ; to Sandham, "On the History of Paddle-Wheel Steam Navigation," in the *Proceedings* of the Institution of Mechanical Engineers, 1885, page 121 ; and also to a handbook, now apparently passing through the press, for the collection of marine models at South Kensington, by Mr. G. Holmes, the secretary of the Institution of Naval Architects. The names of Wood, Steel, Scott, Denny, Caird, and the Napiers are also mentioned, and reference is made to such vessels as the *Rob Roy*, *Robert Bruce*, *Superb*, *Eclipse*, and *James Watt*. The *Savannah*, which made her voyage in 1819, opens the epoch of Atlantic steam navigation, although this ship crossed the Northern Ocean partly under sail, and it was not until 1838, just 50 years ago, that Transatlantic steam navigation became a commercial fact, when the *Sirius* and *Great Western* crossed to America. This brings us to the establishment of the great Atlantic steam lines and the Peninsular & Oriental Company, since which time the progress of events in this connection has been indeed one of the most stupendous facts in this century of engineering marvels. We need not sketch the development of the marine engine through its various stages from those early low-pressure days to the present epoch of steam at 180 lbs., and triple or quadruple engines fitted in such floating mammoths of speed and power as the *City of New York* just starting on her maiden voyage, or the Inman liners *Majestic* and her sister ship now building at the great Belfast shipyard."

English Fast Trains.—On August 6, the first day of the great 400-mile race between two of the biggest English companies, the "Flying Scotchman" was beaten by the "West Coast Flyer." The faster train of the two traversed the greater part of the distance at a speed of a mile a minute.

Competition between the Great Northern and the London & Northwestern companies began to grow lively a year ago when the former, by adding third-class compartments to its Edinburgh limited express, took away the third-class passengers which the Northwestern had hitherto carried on trains going at a somewhat slower speed. Since that time the contest for Edinburgh travel has been active.

As the "Flying Scotchman" on the old nine-hour schedule was the fastest train in the world, the interest taken in the race between the two trains, when both were sent through in eight hours, was naturally great in railway circles and everywhere else.

The two trains pulled out at the same moment, the "Scotchman" from King's Cross Station and the "West Coast" from Euston Station, London. The engine of the "West Coast" had a single pair of driving-wheels 7 ft. 6 in. in diameter, and weighed 27 tons. It burned 24 lbs. of coal per mile during the run. The tender, loaded, weighed 25 tons. Behind it were four coaches filled with passengers, making a weight of 20 tons each, or 80 tons in all.

The entire distance covered by the "West Coast" was 400 miles, and the actual time, excluding stops, was 7 hours and 25 minutes, an average of $53\frac{83}{89}$ miles per hour. This has never been approached before on an English railroad for so long a run. The fastest continuous record in England hitherto was that of the special train which took the Prince of Wales from Liverpool to London, 200 miles, in 3 hours and 59 minutes, an average slightly over 57 miles.

The "Flying Scotchman" ran into Waverly Station on time, but had been beaten not only 7 minutes in time, but 8 miles in distance.

Some details of this initial run may be of interest. From Euston Station to Tring, 31½ miles, generally up grade, the steepest portion being 1 in 70, occupied 40 minutes, and 15 miles, generally down grade from Tring to Bletchley, took only 12½ minutes, the average speed being 72 miles per hour. The distance from London to Tamworth, 110 miles, was made in exactly 120 minutes, while the 48 miles from Tamworth to Crewe took 58 minutes, making the run of 158 miles from London to Crewe without a stop occupy 178 minutes. The second run without a stop was made from Crewe (where the engine was changed) to Preston, 51 miles, and this was done in exactly 51 minutes. A stop of 20 minutes was made at Preston, and on leaving that station there was one run of 88½ miles without a stop. At Carlisle the engines were changed ; the best time made on this section was 31 miles from Shap to Carlisle in 31 minutes, the slowest being the 5½ miles up Shap grade, which took 8½ minutes. The 101 miles from Carlisle to Edinburgh was made in 104 minutes, this distance including the Beattock grade of 10 miles long on an incline of 1 in 80, where the speed was reduced to 44½ miles per hour.

This speed, although much higher than any made regularly in this country, was exceeded on the West Shore road some years ago, when the 425 miles from Buffalo to Weehawken was made at an average speed of 54 miles an hour.

A Torpedo-Boat at Sea.—A correspondent of the London *Standard* gives an account of the voyage from Portland to Berehaven of the torpedo gunboat *Sandfly*. This vessel and her sister boats, it may be stated, are supposed to combine seaworthiness and great speed with vast power of destruction. She is only 8 ft. deep, 23 ft. beam, 200 ft. long, and 450 tons burden. She is rated as a 19-knot boat, and capable of steaming 3,000 miles and more at 10 knots without coaling. Her fighting capacity lies in a 4-in. breech-loading gun, six machine-guns, and four torpedo-tubes. The correspondent says :

"Rams, torpedoes, and machine-guns have lost their terror for the officers of the *Sandfly*, all because she has steamed from England to Ireland in a light breeze and easy seas without going to the bottom with all on board. Three sister boats are taking part in these maneuvers, whose crews may yet be alive to tell of what they have passed through ; but, lest they all have shared the fate of the *Sandfly*—by no means an extraordinary hypothesis—let me record something about the capacity of this species of craft to inflict torture upon the servants of the Queen, too plucky to shirk the work and too well trained to complain. Whatever may be the qualities of the *Sandfly* in smooth waters, the experience of her officers on the run over illustrates her value for such purposes as she is now put to. From their statements it seems that in the light weather we had all the way from Portland, while the *Hercules* moved with the least possible motion, the *Sandfly* pitched and rolled so violently that the pendulum intended to register the heeling of the vessel proved useless. It registers only 30 degrees on either side, and the *Sandfly* rolled nearly 45, the pendulum striking from side to side. This violence of motion succeeded in knocking the poor surgeon from his chair, and pitching him about in the saloon, until he gave up the struggle with several injuries to the ribs. The ship's company to a man were sick as men never were before. One man finally vomited blood, and the best of them had barely the heart left to stand at their posts, seamen and officers alternating at the lee rail in misery. On the bridge, which is as high as the funnels, the seas dashed up as they do against a cliff, lashing the salt wash into the eyes of those on watch, until cayenne pepper could not have made them smart more. In fact, one man has his eyes bandaged. Forward of this bridge no man can go, for it is as freely under water as the bows of a cayak ; and the 4-in. breech-loader that stands there might as well be a champagne-bottle, for any harm it could do an enemy while the vessel is under way. This was most conclusively shown on the journey hither, for the *Warspite* was chased and overhauled by the *Amphion*, of the other fleet, and would surely have been sent to the bottom had actual war existed, for the *Amphion* steamed easily her 15 knots high out of water, while the *Sandfly* could make but 6 knots on the waves, and then rolled and pitched, so that fighting of any kind was totally out of the question. That she can neither make speed nor fight at sea is evident, and what is worse, it is, in the mind of her officers, an even chance whether on any open sea distance she would reach her destination. This short run has so battered her that ever since we have been here she has been undergoing repairs. Her machinery has all the intricacy of clockwork, with much of its fragility. The slightest imperfection anywhere disables her, and not one on board was sanguine enough to think she could float long unless she could keep her head to the sea. Her deck is so close to the water that you can sit and dip your toes in the water over the side, as was the case in the original monitors of the American Navy, but, unlike those vessels, she has bulwarks that hold the water when it rushes over the side, and so destroy the ship's chance of freeing herself rapidly. So low is the vesel, so quick her rolling, and so high her bulwarks, that it would require but a few green seas in succession on board to swamp her effectively. What the boat can do in smooth water is no doubt great, but as a war vessel for general use she has proved a complete failure."

Edison's Phonograph.—Recently a letter appeared in the London *Mail* from Colonel Gouraud, Mr. Edison's agent in England, describing the arrival of the new phonograph which the great inventor has for some time past been engaged in completing. It will be remembered that the first phonograph which was contrived by Mr. Edison many years ago was not a success. It contained a metal cylinder, over which was stretched a smooth sheet of tinfoil, and which could be made to revolve by turning a handle. The sounds were received by a mica diaphragm, from the center of which projected a needle or style, with its free extremity resting upon the tinfoil. Sound waves impinging upon the diaphragm produced vibrations, which were communicated to the style, and caused it to make indentations in the tinfoil ; and these indentations, by putting the cylinder into revolution while a forward movement was impressed upon the style, were extended into a continuous spiral line. In order to reproduce sounds, the process was reversed, the point of the style being brought back to the commencement of the spiral line which it had traced, and the cylinder being again made to revolve. Then, just as the style had been originally thrown into definite movements by the vibrations of the diaphragm, so the diaphragm in its turn was thrown into definite vibrations by the movements of the style, and the sounds which had in the first instance traced the line were again excited by its agency. The diaphragm was contained within a tube, into the mouth of which it was necessary to speak ; and the reproduced voice, although accurate as far as the repetition of words was concerned, was not accurate in the reproduction of tones or other individual characteristics. The words were more or less "bleated," and the original speaker could not in any case be identified with certainty. The tinfoil could not be removed without destroying the trace ; so that a given sound could only be reproduced by the instrument which had received it, and only so long as the foil remained undisturbed and uninjured. The phonograph was used in order to illustrate a principle, by popular lecturers on science ; but was otherwise scarcely more than an ingenious toy.

Mr. Edison, although his attention was long diverted from the phonograph by the pressure of other demands upon him, appears always to have believed in its perfectibility, and in the wide range of its ultimate applications ; and, for the last year, he has devoted himself closely to the subject. In order to attain scientific perfection, it was necessary to replace the tinfoil by some substance which yielded more readily, and more accurately in minute particulars, to the varying pressure of the style, and which yet, either in its original form or after some simple process of hardening, should possess sufficient firmness to guide the style with absolute correctness for the reproduction of sound. It was also necessary to provide for identity of speed in the revolutions of the cylinder, whether this was receiving sound or transmitting it ; and to secure the maintenance of this identity of speed in all the instruments which might be manufactured. For purposes of practical utility, it was further necessary to obtain a recording material which would bear transmission from place to place, or transference from one instrument to another, and which would admit of being accurately copied by electrotype or other processes, and, in this way, of being indefinitely multiplied. All these ends have now been completely or approximately attained ; and the phonograph has acquired a form in which it promises shortly to be accessible to the public for a great variety of uses. The tracings of the style are received upon a material which is shaped into cylinders, and these cylinders can be slipped on or off the fixed spindle of the machine. They are of such a quality as to record and reproduce with great accuracy ; they can be multiplied indefinitely ; they can be transmitted from place to place, or transferred from one phonograph to another ; and they will repeat for an indefinite number of times the words or other sounds which they have received. The words and messages mentioned by Colonel Gouraud, for example, were spoken in the first place to an instrument in Mr. Edison's laboratory, the cylinders which received them were removed, packed up, sent across the Atlantic, and finally placed upon another instrument at Norwood. As soon as this second instrument is set in motion, the words are repeated in voices which appear to be perfectly natural.

Like all other great contrivances, it may have its evil or dangerous applications ; but there can be no doubt that these will be enormously overbalanced by its utility, and, even if they were not, it would be impossible to withhold the tribute of admiration which is justly due to the genius and the industry of the inventor.

THE RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

PUBLISHED MONTHLY AT NO. 45 BROADWAY, NEW YORK.

M. N. FORNEY, ... Editor and Proprietor.
FREDERICK HOBART. . . . . Associate Editor.

Entered at the Post Office at New York City as Second-Class Mail Matter.

SUBSCRIPTION RATES.

Subscription, per annum, Postage prepaid..............$3 00
Subscription, per annum, Foreign Countries............ 3 50
Single copies.. 25

Remittances should be made by Express Money-Order, Draft, P. O. Money-Order or Registered Letter.

MR. J. HOWARD BARNARD, 7 Montgomery Avenue, San Francisco, Cal., is the authorized Western Agent for the JOURNAL.

MR. FREDERIC ALGAR, Nos. 11 and 12 Clements Lane, Lombard Street, London, E. C., England, is the authorized European Agent for the JOURNAL.

NEW YORK, OCTOBER, 1888.

THE river portion of the Poughkeepsie Bridge is finished, the two ends of the last cantilever span having been connected August 30. A part of the viaduct which extends from the end of the bridge proper to the high land on the eastern side of the river is still to be built, but this involves no difficult work and can be done in a short time, if the material is at hand. From present appearances the bridge could be made ready for the passage of trains in October.

The railroad which is to form the main connection with the bridge on the western side of the Hudson is, however, still in an unfinished condition; there is much grading to be done, and track-laying has hardly been begun. It does not seem probable that trains will use the bridge regularly before the Spring of 1889.

CAR-BUILDING is becoming an important industry in the South, where only a few years ago there was but a single place—at Chattanooga—outside of the railroad shops, where cars were built, and that was only a small affair. The Baltimore *Manufacturers' Record* in a recent number published a long list of the shops in Virginia, Georgia, Alabama, and other States, with an account of the work which they are doing and the orders they are filling. It is only a year ago that one Southern shop—the Roanoke Works in Virginia—took from its Northern competitors a heavy order for a New England road, and others may be expected to follow, though at present all are busy on orders for Southern roads.

The Southern shops have the advantage of nearness to timber of the best quality, and most of them can also procure their iron with only charges for a short haul upon it; the cheapness of the iron supply is likely to increase also as the iron manufacture in the South is developed. It is probable that the Southern shops will be an element of growing importance in car manufacture, and that their competition will be felt more and more for several years to come.

THE control of the East Tennessee, Virginia & Georgia Railroad, which has for some time been held by the Richmond & West Point Terminal Company, will very probably be transferred to the Norfolk & Western Railroad Company in a short time, negotiations to that effect being now in progress. The East Tennessee line is a natural connection and continuation of the Norfolk & Western, and can be handled in connection with that road much better than with the Richmond & Danville, so that the transfer will probably benefit all parties to the agreement.

WORK is now well advanced on the change of the Toledo, St. Louis & Kansas City Railroad, nearly two-thirds of the main line from Toledo to East St. Louis having been altered from three feet to standard gauge, while the change of the entire line will probably be completed in October. The Cleveland & Canton Railroad will also be changed from three feet to standard gauge during October, the work being now in progress.

The change of these two roads marks the practical disappearance of the narrow gauge east of the Rocky Mountains, the only lines still of that gauge being a few short local roads scattered here and there, to most of which—as, for instance, those in the Catskill Mountain region—the break of gauge with their connections is of very small importance. The three-feet gauge which, according to the predictions of its advocates, was to supersede all the broader gauges, has thus proved an unsuccessful and somewhat costly experiment. Even the mountain lines in Colorado and Utah have decided to abandon it as soon as practicable.

ACCORDING to Russian authorities the new Transcaspian Railroad promises to be a good investment from a commercial as well as from a military point of view. The line is not only beginning to carry a large traffic heretofore left to caravans, but the ancient cities upon it have begun to increase their business, and to draw to themselves a considerable commerce. Moreover, preparations are being made to increase largely the productive capacity of the country along the line, much of which was in former ages cultivated by irrigation, and it is believed can again be made fertile in the same way. Chief among these undertakings is the restoration of the dyke of Sultan Bente on the Mourghab River, which was destroyed over 300 years ago. The waters of the Mourghab, which are now lost in the desert, were, when this dyke was in use, stored up, and served to irrigate an area of nearly 800,000 acres of land, which was once considered the most fertile part of Central Asia, but which has, since the water has been wasted, been practically a desert. The climate and soil are said to be especially adapted for the cultivation of cotton, and Russian engineers claim that with irrigation this district can be made to produce all the cotton required in their own country, with possibly a surplus for export, while the railroad will furnish means for transportation. Other similar and lesser schemes have been brought forward, and will probably be taken up as soon as the greater ones are well advanced.

It is also expected that with the completion of this road, and the opening of certain new highways, on which work

has been already begun, the Transcaspian line will in time become the great artery of commerce for Khorassan and all of Northern Persia.

ONE of the oldest engineering projects in the world is now gradually approaching completion, and the work will probably be finished during the coming year. This is the canal through the Isthmus of Corinth in Greece, which was first planned some 25 centuries ago, and on which work was actually begun under the Emperor Nero, so that over 1,700 years will have passed between its beginning and its final completion. As finally excavated the canal will be four miles long, with a depth of eight meters, or sufficient for the largest vessels which usually navigate the adjacent seas.

It was expected that the canal could be opened about the close of the present year, but the engineers have decided that to secure permanence, and to avoid continual obstructions and expensive dredging, it will be necessary to build retaining walls on a section about 1¾ miles long, where the excavation is through a light sandy soil which cannot be made to form permanent banks.

The total cost of the canal will be about $9,000,000 or $4,000,000 more than the original estimate. Some doubt is expressed as to the possibility of levying sufficient tolls on the commerce which is likely to use the canal to pay interest on this cost.

The work, it is stated, has been very substantially done, and the cost of maintenance will probably be very light. It has been carried out under the direction of French engineers.

ARMY appropriations, after long dispute between the two Houses of Congress, have been finally settled by a conference committee, whose report covers both the Army Bill and the Fortification Bill. The provisions of the two bills were in a great measure interdependent, the Senate having largely amended one, and inserted appropriations which came from the House in the other. The ordinary appropriations for the maintenance of the Army are substantially the same as usual; the special appropriations over which the dispute arose are larger than provided in the House, but smaller than the Senate desired. These special appropriations include $200,000 for the manufacture of field guns and carriages; $250,000 for rifled mortars; $700,000 for the new gun factory at the Watervliet Arsenal; $1,500,000 for the purchase of rough-bored steel forging for guns; $500,000 for the purchase and test of guns by the Ordnance Board; $100,000 for testing pneumatic guns and shell, and $200,000 for tests and experiments of submarine mines and torpedoes. These appropriations, though not all that were asked for, will supply funds for a great deal of serviceable work during the coming year.

A PROPOSITION was made during the discussion of the Naval Bill in the United States Senate, to provide as an addition to the Navy a really formidable fighting ship of 15,000 tons displacement. Some Senators seemed to think that such a proposition was intended more as a joke than anything else, but while such a vessel would far exceed in size anything now under construction or heretofore proposed for our own Navy, it would really be not much larger than some owned by European nations. The Italian Government, which has always favored heavy ships, is now building one of 13,900 ton displacement, and a 15,000-ton vessel would be really very little larger. The policy of building such a warship may, however, be doubted, and several smaller vessels, which would cost about the same amount, would be of far greater use to us.

THE season of instruction at the Naval War College at Newport has arrived, and the sessions of the College have been resumed under direction of the Navy Department, although its work is somewhat limited by the failure of Congress to make specific appropriations for its support. The course of lectures this year on Naval Tactics, Coast Defenses, Strategy and National Law, will be very similar to that of last year, and will be doubtless equally beneficial to the naval officers who are permitted to attend. A proposition has been made in the Senate to establish the War College on a permanent basis, and to consolidate with it the School of Torpedo Instruction, which has been carried on at Newport for several years past. Another proposition has been made for the removal of the College to Annapolis, and its permanent establishment there as a department of the Naval Academy, but this does not seem to meet with much favor, and, indeed, Newport, or rather Shooter's Island, seems to be a place much better fitted for the purpose.

A CURIOUS controversy has arisen between the United States Light-House Board and the Trustees of the Brooklyn Bridge. The bridge roadway is lighted by a number of electric lights placed at intervals along the parapets, which serve their purpose very well, so far as the bridge is concerned, but which, it is claimed by the Light-House officials, are very confusing to the pilots of vessels navigating the East River. They say that the only lights which should be placed upon the bridge so as to be visible from the water should be the red and green signals which the law requires for all bridges over navigable waters. The Trustees, on the other hand, assert that the bridge lights are so far above the water that they cannot possibly interfere with navigation or deceive pilots, and, furthermore, that it is necessary to public safety that the bridge should be well lighted. As it is not a draw-bridge, and is high enough above the water to permit vessels to pass beneath the structure, they claim that as long as proper lights are shown on the piers no complaint can be made. The question is still unsettled, as the Trustees have positively declined to give way, and the Light-House Board has requested the United States District-Attorney to bring suit to enforce its orders.

It seems probable that this suit will be successful, and in that case the matter could very easily be arranged by shading or shielding the lights so that they would not be visible from the water below, and this would rather increase than diminish their efficiency so far as the lighting of the bridge roadway is concerned.

RAILROAD schools as such are not known in this country, and outside of the engineering departments, which are now largely recruited from the technical schools, no special preparation for railroad employment is required, those who are in it generally gaining their knowledge in actual, practical service. The article submitted by M. Bela Ambrosovics to the International Railroad Congress,

which is translated on another page, illustrates sharply two points of difference between our own and European railroads: the extent to which Government control is carried, and the preparation thought necessary for employés. In Hungary the State interests itself in the smallest details of management, and not only regulates the general administration of the lines, but also prescribes the manner in which the employés shall be appointed and the rules which govern their conduct. That it should also arrange a special course of study to prepare them for their work follows as a natural consequence, and the State railroad school is the logical outgrowth of State control from the European point of view.

The education of the civil and mechanical engineers of the railroads had already been provided for in the technical schools; and the railroad school which the Hungarian Government has established at Buda-Pesth is to train employés for the station service, the traffic department, and the general offices, fitting them to enter the lower ranks, and to be ready, when practical work has completed the education begun theoretically in the school, for promotion to the higher grades of the service. There can be no doubt that the idea is a good one, and that the employé will be better fitted for his work after going through the course; especially as it seems that the practical training is not to be neglected for the theoretical, but is to be an essential part of what is required of the man before a permanent position is secured to him.

One condition favoring the establishment of such a school, which exists in Europe, but is entirely lacking in this country, is the permanent nature of employment there. The young man who is appointed to a subordinate position at a station there looks forward to a lifetime to be spent in the work, and expects no change except the slow and gradual promotion which may come to him from time to time. He hopes to rise in the course of years, but has no idea of leaving the road voluntarily; he does not take it up as a temporary expedient, a "job," to be left as soon as something better offers, as his fellow-employé in this country wou'd do, and does do, and therefore he can afford to spend time in preliminary preparation which would here be considered as thrown away.

A second condition which would make the establishment of such a school difficult, if not impossible here, is the absence of any authority which could make the employment of its graduates compulsory, or even give them preference over others in appointments. The difficulty of securing concerted action of two or more companies in this direction would be another obstacle not easy to overcome.

That the establishment of such a school here is not to be expected, is, perhaps, one of the disadvantages inherent in our system of railroad management; whether this—and others which might be mentioned—are not more than counterbalanced by the advantages, is a question too broad for discussion here.

THE Indian Railroads last year were hardly as prosperous as usual, the Government statement showing a considerable falling off in business, with very little in expenses, so that there was not only a loss in the lines owned directly by the Government, but a considerable amount was also required to make up the dividends of the guaranteed companies. The decrease in earnings was largely due to the depressed state of the grain trade, which affected the receipts of the principal lines; but, nevertheless, it is stated that the total tonnage of merchandise carried was increased by over 1,000,000 tons; the ton-mileage is not given, so that it is probable the average haul decreased.

The total mileage operated at the end of the year was 14,583 miles, and there are now 2,000 miles more under construction or survey. The new lines built last year were not very great in length, and were chiefly in Northwestern India, although an important addition was made in the lower part of the country by the opening of the Southern Mahratta Railroad. Commercially, the most important lines opened in Northern India were several branches of the Northwestern Railroad, but the line which has attracted the most attention has been the military road to the Afghan frontier, which has been completed from Sibi to Kilia-Abdulla and up through the Bolan Pass, while work on its extension is in progress, and preparations have been made to begin the construction of the great Khojak Tunnel.

Some important improvements were made last year on the Indian lines, chiefly in the way of improving connections between the different roads and in substituting bridges for ferries. Prominent among these were the Kalpi Bridge over the Jumna, the Betwa Bridge, the Sukkur Bridge over the Indus, the Ferok Bridge on the Madras Railroad, the Balawali and Dufferin bridges on the Oudh & Rohilkhand Railroad. A good deal has been done in the way of substituting heavy steel rails and iron ties for the old iron rails on wooden ties on the South Indian and other roads.

While a large part of the work has been done by private or guaranteed companies, the Government has had two important military lines in hand, the Afghan frontier line, on which, judging from local comments, the progress made has been anything but satisfactory, and the extension of the Burmah State Railroad from Toungoo to Mandalay, which is now nearly completed, and on which some very rapid work has been done.

It is interesting to note that the narrow gauge is being gradually abandoned in India as well as in this country, and one of the events of the year was the changing of the Nagpur-Chattisgarh meter-gauge line, about 140 miles long, to the broad gauge.

LOCOMOTIVE BOILERS.

IT is understood very clearly now that a locomotive with an inefficient boiler is like a man with an unhealthy stomach, and that the source of power and speed in locomotives, as in human beings, is in their digestive organs. Locomotive builders and those in charge of the motive power of railroads have been slow to recognize the importance of sufficient boiler capacity, and for a long time the aim of the designers of these machines seemed to be to ascertain the minimum size of the steam-generator that would answer for the service in which they were to be employed. The attitude of mind in which such engineers seemed to entertain the question was apparently similar to that of inexperienced persons in relation to frictional bearing-surface. The natural man, who has never passed through a period of contrition for his shortcomings—which experience of hot bearings is sure to impose sooner or later—seems to abhor amplitude of bearing-surface. Hot boxes appear to be as essential to quicken the perceptions of young mechanics and engineers, with reference to

this subject, as the fires of sheol are to awaken the consciences of sinners generally. So with reference to boilers. The unregenerate mechanic seems to abhor large boilers. It is only when he has been through a sort of penitential experience with locomotives, when one of them gets out of steam in trying to pull a train up a heavy grade, and it utters what seems like a gasp, and, in the vernacular of the road, it "lays down" in despair, that he realizes their necessity. The endurance of a man, the speed of a horse, and the power of a locomotive all depend upon their breath holding out. Experience has thus finally taught those who have given due attention to the subject, that a sufficient supply of the breath of life in locomotives is dependent upon ample boiler capacity.

The question has then been asked, and last year was submitted to a committee of the Master Mechanics' Association, how big should a locomotive boiler be? The committee submitted their answer in a report to the last convention of the Association, and the rule given in that report for calculating the heating surface of a locomotive boiler for engines with cylinders of 24-in. stroke, was that *the area of one piston in square inches should be multiplied by* 5.8, *and the product would be the total heating surface in square feet.* At first sight it might appear as though this rule does not take due account of the size of the wheels, as, other things being equal, the diameter of the cylinders would be increased with that of the wheels. But the diameter of the wheels should be proportioned to the speed of the engine. Thus, suppose we have an engine with wheels 4 ft., and cylinders 18 in. in diameter, and that the wheels make 200 revolutions per minute. The area of such a piston would be 1.767 square feet, so that the spaces swept through by the two pistons, and, consequently, the quantity of steam used per minute, would be equal to $1.767 \times 2 \times 4 \times 200 = 2,827.2$ cubic feet. If an engine was built to run 50 per cent. faster, the diameter of its wheels and cylinders should be increased in like proportion, so that the area of its pistons should each be 2.65 square feet, and, therefore, if the engine ran the same number of revolutions per minute—which would mean 50 per cent. greater speed—it would consume 4,240 cubic feet of steam per minute. By the rule which has been given, the heating surface in the one case should be 1,476, and the other 2,214 square feet. But here we encounter a difficulty. If the two engines are of a similar plan, say of the eight-wheeled American type, with four driving-wheels and a four-wheeled truck, it will be found that the running gear, cylinders, their connections, and the frames of the engine with the large wheels, must be all larger and heavier than those of the other engine, while at the same time the boiler of the one with the large wheels should be larger than that of the one with the small wheels. Let it be supposed that the weight of the engine with the small wheels is as follows:

Total weight........................	96,000 lbs.
Weight of boiler, with water and fuel..	40,000 "
" " wheels, cylinders, frames, etc.	40,000 "
" " other parts	16,000 "

Now, if the size of the wheels and cylinders is increased 50 per cent., they will weigh 60,000 lbs., instead of 40,000. If this weight, added to that of the other parts, is deducted from the total weight, then there will be only 20,000 lbs. left for the weight of the boiler. That is, the boiler which should be the largest must weigh the least. In practice, slow-running engines have a larger proportion of their weight on the driving-wheels, which makes it essential that the cylinders should be larger, as is the case in ten-wheeled, Mogul, and consolidation engines, and fast-running locomotives have less weight on the driving-wheels, as in the case of the English machines with only one pair of driving-wheels, and thus the size of the cylinders is kept down, and, consequently, not so large a boiler is demanded.

It therefore seems as though the problem might be approached most advantageously from another side. Thus, supposing we determine from experience what class of engines is best suited for a given service. The weight of the rails will determine the load per wheel which may be carried, and it and the diameter of the wheels will decide what the size of the cylinders should be, which in turn will govern their weight and that of their connections. Having advanced this far, if we take their weight, and that of all the other parts, excepting the boiler and its attachments, and deduct it from the total weight of the engine, which has been determined by the load to be carried on each of the wheels and their number, the remainder will be the weight of the boiler. It is quite safe to say that within this weight the boiler cannot be made too large, and the problem therefore is, how to make the largest boiler of a given weight, and, of course, of the requisite strength.

Under these conditions, the only way to add to the weight and size of the boiler is to reduce the weight of the other parts. To this end it is desirable to keep the diameter of the wheels as small as possible, because with a given weight on them the size of cylinders and their connections is proportioned to that of the wheels, and therefore if all these parts are small and light the boiler may be larger and heavier, and yet keep the total weight of the engine within the prescribed limits. In designing locomotives, then, it would seem that there is a decided advantage in keeping the weight of all the parts not connected with the boiler as small and light as is practicable, so that the dimensions of the latter may be increased. It is also desirable that the lightest form of construction for boilers should be adopted, so that they may be of the maximum size and capacity. Forms of construction which require the use of heavy braces and stays should be ignored, and the preference given to plans which will make a boiler of the maximum size and strength, and the minimum weight. The maxim is undoubtedly true that "within the limits of weight and space to which a locomotive boiler is necessarily confined, it cannot be too large." This being true, it would seem to be worth while in building locomotives to give especial care to the designs of all the parts which do not form a part of the boiler, and are not attached to it, with a view to reducing their weight, because every pound taken from these parts may be added to the boiler.

With the increase of the size of locomotives another difficulty is encountered. The gauge of the rails is fixed, and, consequently, the distance between the frames—if they are placed inside of the wheels, and are of the usual form employed on American locomotives—is limited to about 42 or 44 inches. When the barrel of the boiler is made from 60 to 70 inches in diameter, the fire-box is relatively very much contracted, and the back view of such a structure reminds one of a broad-shouldered woman who is tightly laced. Under these conditions, both her vitals and those of the locomotive are unduly and injuriously

contracted. To put the fire-box above the frames, and thus get from six to eight inches additional width, is open to some objections, although these are, perhaps, counterbalanced by the advantages gained. To put it above the wheels is open to still greater objections.

The problem then presents itself, how to get a wider fire-box for the large engines which are demanded by the traffic of the time than is possible with the present plans of construction. This problem is daily becoming more urgent, and a solution of it would be an improvement in locomotive construction which is urgently demanded.

The Sewerage of Cities.

IN the article on this subject, the concluding chapter of which was published in our September number, M. Mayer, a distinguished French engineer, although speaking exclusively of matters in his own country, curiously illustrates the existing state of affairs in this country, and his remarks are quite as applicable here as to those for whom they were especially written. The great importance of a systematic treatment of the subject has not been and is not at all realized among us, for while it is generally admitted that sewers are needed, the question has usually been allowed to go by default, as it were, and very few attempts have been made at a thorough consideration of this subject, which is next to that of the water supply in its effect on the public health.

We do not mean by this to depreciate the value of the work which has been done in this country by Waring, Shone, and other prominent engineers, or the less conspicuous but faithful work which has been done in many places by conscientious engineers who have worked hard to do their duty in face of a very discouraging public indifference on the subject.

The trouble always has been the lack of thorough study. In the majority of cases the sewers of a town or village are begun without any careful consideration of the subject, and as the town grows additions to the system are put in here and there as needed at haphazard, with no general plan, and often without any calculation for the present or for the future. It is the exception rather than the rule to find in our smaller towns any general collecting sewer, and not only there, but in many large cities instances can be multiplied where a 24 in. discharges into an 18-in. pipe, and other blunders of the same kind have been made.

Even where some attempt has been made at proper planning and arrangement, there has been no disposition to keep in view the true object of a system of sewers, which is, as M. Mayer says, to carry off foul water alone, the solid refuse, or garbage as we call it, being left to be disposed of in a different way. Then, too, the rain-water to be disposed of is too often merely guessed at, or perhaps not considered at all, and even when some rough allowance is made for it, no attempt is made to estimate the quantity which must be provided for or to consider the nature of the ground, the kind of street pavements, and many other matters which must be taken into account.

Especial attention might be paid to what M. Mayer says in relation to land drainage, and too much emphasis cannot be put upon the fact that the drainage of low ground is not one of the proper functions of city sewers, and should be provided for by a separate system, the cost of which should be borne entirely by the property benefited, and should be regulated by local circumstances. As a rule in this country, where there is an abundant opportunity for the selection of proper sites for towns, low swampy ground is not taken in the first place, and where the growth of the city makes it expedient to take in such ground, the profit accruing to the owners is usually quite sufficient to enable them to bear without hardship the cost of such special works as may be needed.

One important matter, which has as yet received no consideration whatever here, is the disposal of sewage, a problem which increases in difficulty very rapidly with the growth of a town, and which, as a rule, cannot be treated in a general way, but must be in each case made a special study. Our habit has been to meet this case in the easiest possible way, and this has too often resulted in simply discharging the refuse of a city into the nearest river, allowing it to pollute the water and to become a danger and a nuisance to other towns. We have not yet begun to realize what can be and should be done in this direction, and no serious attempt has been made to utilize city waste, even in the more densely populated portions of the country.

It is well to bear carefully in mind the general principles laid down for designing a system of sewers, either for a large or for a small town, and the many factors which come into the case—the nature of the ground, the surface, the fall to be obtained, the kind of houses, the proportion of the surface occupied by buildings, and many other matters. A district, for instance, occupied by a purely resident population needs very different facilities from one where there are many factories, just as one covered by the small houses and gardens of a rural city presents conditions widely different from one inhabited by a dense tenement population, as in such cities as New York and Boston. In the case of the smaller cities, to which these articles are especially applicable, the nature of the water supply must always be carefully considered, its quantity, the head of water, and the force of current which can be used. It is hardly necessary here, where every town expects in the future to be the leading one of its State, to caution engineers to make allowance for future growth.

One of the most difficult of the questions which usually confront an engineer in this country is the financial one. It might be said that this does not properly fall within his province, but it is nevertheless true that he is obliged to consider it. He must remember that in planning a system of works which is to be paid for by the people, it will be necessary to make one which is worth what it costs, and which so far as possible presents a value which can be estimated in money by those who pay for it. He must consider the ability to pay, and must not, in estimating the value which proper sewerage will add to property, make it cost so much as to impoverish the present owners. He must also remember that the increment of value in property cannot always be expressed in money, and that the advantage to public health is sometimes very difficult to put down in dollars and cents. A reduction in the death-rate of a city is excellent, but not always a thing which can be credited on a ledger.

The true value of sanitary work is, perhaps, one of the hardest things to express definitely; it has been claimed that the only true test is the difference in rental value of property before and after sanitary work is undertaken, but even this is often an unreliable guide.

The manner in which such works are to be paid for is another question which falls outside the engineer's prov-

ince, but which nevertheless very often affects the limits placed upon his work; and it may frequently happen that he will be consulted in the matter. Of course no general rule can be laid down in such cases beyond making the suggestion that it is perfectly fair to put upon posterity, in part at least, the burden of any works which will probably benefit them more than the present generation. The only general principle which can be laid down is to insist upon the closest economy which is consistent with good and thorough work. Fortunately, it is hardly necessary to remind the present generation of engineers that such economy is only consistent with the strictest professional integrity.

NEW PUBLICATIONS.

NAVAL RESERVES, TRAINING AND MATÉRIEL: NAVAL INTELLIGENCE, GENERAL INFORMATION SERIES, NO. VII., JUNE, 1888. ISSUED FROM THE OFFICE OF NAVAL INTELLIGENCE, BUREAU OF NAVIGATION, NAVY DEPARTMENT. Washington; Government Printing Office.

The title given to the present number of *Naval Intelligence* is taken from the leading paper, which is on Naval Reserves and Coast Defense, and is by Lieutenant J. C. Colwell, U. S. N. This paper starts with a brief statement of the extraordinary fact that the United States is the only maritime nation in the world which makes no provision whatever for a reserve force for its Navy, or for the speedy recruiting of its naval force, even to fill up its ordinary quota in time of peace. This statement is further emphasized by a careful account of the provisions made in England, France, Germany and elsewhere for the establishment and thorough organization of a reserve force both of officers and men. The English Naval Reserve has been in existence under various forms for nearly 90 years, having been first formally organized in 1798, and at present has a nominal strength of 920 officers and about 30,000 men, or an actual strength of somewhat over 19,000 actually enrolled; this reserve force alone being 2½ times greater than the entire authorized number of our own Navy. In addition to this there is a further force, which might be effectively used in case of war, consisting of officers on the retired list, coast-guards and others, who could be called upon in case of necessity, and who would be very effective in manning vessels for coast and harbor defense.

In France the reserve system goes much further, the entire male population of the sea-coast districts being enrolled in the *Inscription Maritime*, which includes all fishermen, boatmen, and seamen not only of the coast but on the rivers, to the head of tide-water. These men are included in the enrollment from the age of 18 up to 50, and are liable to be called out for active service at any time; moreover, from the *Inscription Maritime* the active force of the Navy is recruited, such number as may be required—from 2,000 to 2,500 yearly—of the younger men being drawn for service in the same manner as conscripts are drawn for the Army. The term of service of these conscripts in the Navy is seven years, and two years of this term in time of peace are usually passed in the Reserve. The Reserve is divided into two classes: the men of the first class or Active Reserve being liable to a call at any moment; they serve in this class for four years and then pass into the second class, which is only liable to be called upon in time of war or great emergencies. Under the regulations provided a certain exemption is made to pilots, masters of vessels, seamen employed on ships engaged in foreign trade, and men with families. The total number of men included in the *Inscription Maritime* is about 160,000; the number of men in the actual service of the Navy is somewhat over 30,000 usually. It is estimated that nearly one-third of the total enrollment would be available for service. A portion of this reserve, moreover, is drilled and trained yearly in the use of heavy artillery, and could at once be employed in sea-coast forts as well as on shipboard.

The German Naval Reserve is organized with the same thoroughness as the Army of that country, to which its administration corresponds very closely. As in France, it includes all seafaring men, and, in fact, a large portion of the sea-coast population. The liability to service in that population is the same as that required for the Army in the inland districts, and every man is obliged to serve some time either as conscript or volunteer in the active naval force. If not required for active service he is enrolled in the Active Reserve, in which he remains for 12 years; at the end of that time those who have completed the required terms, either of active service or training, pass into the *Seewehr*, which corresponds with the *Landwehr* of the Army, and while in that class are liable to be called out at any time. The *Seewehr* has a completely organized force of officers and men, all of whom are called out periodically for training and exercise, and would in case of emergency constitute an exceedingly effective addition to the Navy, ready to man a large number of additional vessels, while, as in France, a sufficient number are trained in the use of heavy artillery to serve in the sea-coast fortifications. After completing their service in the *Seewehr*, the officers and men pass into a third class or reserve, which corresponds to the *Landsturm* of the Army. Lieutenant Colwell's paper also gives accounts of the naval reserves of Russia, Austria, Italy, Spain, Sweden, Holland, Denmark, Portugal, Greece, and Turkey, nearly all being organized on the German system. Japan also has a very excellent system of naval reserves, both officers and men.

A reserve force of officers and seamen is evidently useless unless there are vessels on which they can be employed, and accordingly nearly all the European nations, following the lead of England and France, have adopted systems under which a considerable number of ships employed in mercantile voyages can be taken for war purposes in case of necessity. In England there are fixed rates of charter provided by law, while in France and Italy navigation and construction bounties are paid for all vessels coming up to the requirements of the naval authorities, and in return it is provided that they can be taken for use by the Government in case of emergency. In Russia and Germany all vessels owned are liable to be taken for Government use whenever required, and similar provisions are made in many other countries. In the United States, as is well known, while the question of naval reserves has been much discussed, nothing has been done, and in case any addition to the naval force should be required in a hurry we would have to depend, as in 1861, on the purchase of such vessels as might be picked up by the Government, and on voluntary enlistments.

The second paper in this issue, by Lieutenant S. A. Staunton, is on Naval Training, and gives especial attention to the changes made in foreign navies in the training

of both officers and men, recent progress in ship construction, and in the implements of naval warfare. A third and carefully illustrated paper, by Lieutenant C. E. Vreeland, is on Target Practice Afloat, both in our own and foreign navies. Lieutenant W. H. Beehler gives an account of the manœuvres of the English, French, and Italian navies during the season of 1887, and also a brief account of the manœuvres of the North Atlantic Squadron in the neighborhood of Newport last fall. There are also illustrated articles on Electricity on Shipboard, by Lieutenant J. B. Murdock, and on Marine Boilers, by Passed Assistant Engineer R. F. Griffin ; with shorter articles on the Preservation of the Bottoms of Iron Ships, by Lieutenant Seaton Schroeder, and on the Transportation of Torpedo Boats by Railroad, by Lieutenants W. I. Chambers and A. Sharp.

The longer articles are supplemented, as in the case of former issues of *Naval Intelligence*, by a number of interesting and valuable notes on naval affairs in the United States and abroad. Some extracts from these in relation to our own Navy will be found on another page.

KRUPP AND DE BANGE: BY E. MONTHAYE, CAPTAIN IN THE BELGIAN GENERAL STAFF. TRANSLATED, WITH AN APPENDIX, BY O. E. MICHAELIS, CAPTAIN OF ORDNANCE, UNITED STATES ARMY. New York ; issued by Thomas Prosser & Son, No. 15 Gold Street.

The best known system of modern gun construction is that originated by Herr Krupp, which has been adopted in Germany and other European countries, for which the originator built a great number of guns at his Essen Works. More recently a new system, that of De Bange, which had been adopted in France, has attracted much attention, and an animated discussion is going on in military circles over the comparative merits of the two systems. The present work, which is intended to give a complete account and comparison of the two, is written by an officer of the Belgian Army, who has had, owing to the peculiar neutral political position of his country, special opportunities for studying the practice of other armies. His conclusions, although he has evidently tried to keep an impartial frame of mind, are almost entirely in favor of the Krupp system, and his arguments are supported by a formidable array of facts and statistics. The book is just now of practical interest in this country, as the new experimental high-power guns on which our Army and Navy departments are engaged are of a modified De Bange model.

Captain Michaelis, who has made a special study of the construction and material for heavy ordnance for a number of years past, is especially fitted for the translation and adaptation of this book to our own practice.

The contents of the book include three parts and an appendix. The first part consists of a chapter on Gun Metal, the various kinds used, and their properties ; a chapter on Gun Construction, giving an account of the methods adopted in the two systems ; a chapter on Ballistic Performance, and one on the results attained by the Krupp system in various European states. The second part consists of the arguments and objections raised by the adherents of the Krupp system against the new guns, and gives a description of the two systems of manufacture, concluding with an account of the Belgrade competition of heavy guns, about which so much has been said and written abroad.

The third part is given up to a description of the Krupp Works, and their methods of manufacture, while the appendix is devoted to a defense of the Krupp system of artillery, and some accounts of the failure of different guns in practice.

The book, although it has, as we have said, an evident leaning toward the Krupp system, gives a very fair account of its opponent, and contains much that is valuable and worth study by those who are interested in this subject.

MANUAL OF THE RAILROADS OF THE UNITED STATES FOR 1888: SHOWING THEIR ROUTES AND MILEAGE; STOCKS, BONDS, DEBTS, COST, TRAFFIC, EARNINGS, EXPENSES AND DIVIDENDS; THEIR ORGANIZATION, DIRECTORS, OFFICERS, ETC.: BY HENRY V. POOR. New York ; published by H. V. & H. W. Poor, No. 70 Wall Street.

Poor's Manual has been for so many years the only available source of information concerning our railroads, that it has grown to be indispensable to all who have occasion to use railroad statistics.

It is a curious illustration of the absence of Governmental regulation of railroads in this country, that the only publication which can be referred to, or which can pretend to give an account of all the railroads in the country, is purely a private enterprise, and depends for its facts and figures in great part upon the reports and documents furnished voluntarily by the companies. This state of affairs may be done away with to some extent when the system of reports called for by the Interstate Commerce Commission comes into full operation, but the fact remains that we always have been, and up to the present time, are still dependent on private parties for such figures as we possess in relation to our whole railroad system.

It is due, however, to the publishers of the *Manual* to say that their enterprise has always been conducted with much care and impartiality, so that the book is as reliable as any publication of the kind could well be, without official authority. It cannot be claimed, of course, that it is perfect, or that there is not some opportunity for improvement in details, but the *Manual* has gone far to make up for the absence of official returns.

The summary of railroad business given in the introduction is deprived of part of the value it might have by the variation in the periods covered by the individual reports on which it is based, but it gives as close an approximation to the total as is attainable under present circumstances.

ABOUT BOOKS AND PERIODICALS.

THE MAGAZINE OF AMERICAN HISTORY for September, in a very interesting article on the Centennial Celebration of the Settlement of Ohio at Marietta, has a long account of Colonel Rufus Putnam, who was the most distinguished engineer of the Revolutionary period, and may fairly be styled the Father of American Engineers. Colonel Putnam was the chief engineering officer of the Revolutionary Army. He surveyed and laid out the first purchase of the Ohio Company in the Northwestern Territory, and led the first company of settlers in that territory. He was responsible for the first organization of the public survey of the national territory, and originated the system of laying out townships, which has been in use up to the present day in all Government lands.

In the same number there is reprinted a very curious article from the London *Universal Magazine* for July,

1757, describing the River Ohio, which, in spite of many geographical errors, contains a clear prediction of the future importance of Fort Du Quesne (now Pittsburgh) as a center of commerce for all the Ohio and Mississippi valleys, and also as a great manufacturing point. The writer, whose name is not given, evidently had a clear perception of the natural advantages of the place, though his knowledge of the lower Ohio was rather indefinite.

The leading article in the JOURNAL OF THE MILITARY SERVICE INSTITUTION for September is a long and exhaustive one on Material for Field Artillery for the United States Army, by First Lieutenant A. D. Schenck, Second Artillery; Lieutenant-Colonel Henry M. Lazelle, Twenty-third Infantry, contributes an article on India, the result of his observations on a trip made under orders from the War Department to witness the maneuvers of the army of that country in the winter of 1885–86. There are interesting shorter articles by Lieutenant-Colonel H. Clay Wood, Captain Edward Hunter, and Captain James H. Haynie, and the conclusion of the discussion by the Institution of Lieutenant Weaver's paper on Armament of the Outside Line.

In HARPER'S MAGAZINE for September, Charles Dudley Warner's Sketches of the Great West are continued by somewhat rose-colored descriptions of Memphis and Little Rock. His statements of the growing commercial importance of Memphis as a center of both railroad and river traffic are true; the account of the peculiar municipal condition of the city is interesting, but the experiment must still be regarded as a very doubtful one.

In the October number Mr. Warner talks—for his papers are more familiar talks than formal articles—of St. Louis and Kansas City.

In SCRIBNER'S MAGAZINE for October appears an article on the Railroad in its Business Relations, by Professor Arthur T. Hadley, which treats of the questions of rates, pooling, and Government control. While Professor Hadley is not a railroad man himself, he is well known as a careful student of railroad questions; his lectures in Yale College have earned him a high reputation, and he is well qualified to write on those points which he has taken up.

LIGHT, HEAT, AND POWER, the well-known gas journal published in Philadelphia, opens its fifth volume by changing from a semi-monthly to a weekly form. It is an excellent journal for those interested in this subject, and this evidence of its increasing prosperity is gratifying.

BOOKS RECEIVED.

INSTITUTION OF MECHANICAL ENGINEERS: PROCEEDINGS, MAY, 1888. London, England; published by the Institution.

JOURNAL OF THE IRON AND STEEL INSTITUTE: NO. 1, 1888. London; issued for the Institute by E. & F. N. Spon.

OCCASIONAL PAPERS OF THE INSTITUTION OF CIVIL ENGINEERS. London, England; published by the Institution. The present installment of these papers includes the Tay Viaduct, Dundee, by Crawford Barlow; the Construction of the Tay Viaduct, by William Inglis (with abstract of discussion); Effect of Temperature on the Strength of Railway Axles, Part II by Thomas Andrews; the Prevention and the Extinction of Fires, by Alfred Chatterton; a New Method of Investigation Applied to the Action of Steam-Engine Governors, by Professor V. Dwelshauvers-Dery; the Distribution of Hydraulic Power in London, by Edward B. Ellington.

SCARRITT CAR CHAIRS AND FORNEY SEATS AND CAR FURNITURE: CATALOGUE. Issued by the Scarritt Furniture Company, No. 414 North Fourth Street, St. Louis, Mo.

WATER-SUPPLY IN THE WHOLESALE DISTRICT OF THE CITY OF ST. PAUL, 1888: REPORT MADE TO THE CITY COUNCIL OF ST. PAUL, MINN., BY JOHN W. HILL, CONSULTING ENGINEER. St. Paul, Minn.; published by the Council.

THE OTTAWA NATURALIST: TRANSACTIONS OF THE OTTAWA FIELD NATURALISTS' CLUB FOR THE QUARTER ENDING AUGUST, 1888. Ottawa, Canada; published by the Club.

JOURNAL OF THE NEW ENGLAND WATER-WORKS ASSOCIATION: PROFESSOR GEORGE F. SWAIN AND WALTER H. RICHARDS, EDITORS. New London, Ct.; issued from the Junior Editor's office. The present number contains the proceedings of the Seventh Annual Convention of the Association, which was held in Providence, R. I., June 13, 14, and 15, with all papers read at that meeting and the discussions thereon.

PROCEEDINGS OF THE MICHIGAN ENGINEERING SOCIETY AT THE NINTH ANNUAL CONVENTION, HELD IN KALAMAZOO, MICH., JANUARY 17-20, 1888. Climax, Mich.; published by F. Hodgman, Secretary.

AIR-COMPRESSORS, ROCK DRILLS, ETC.: CATALOGUE NO. VI OF THE CLAYTON AIR-COMPRESSOR WORKS. New York; No. 43 Dey Street.

THE PHILOSOPHY AND PRACTICE OF MORSE TELEGRAPHY: BY T. JARRARD SMITH. New York; issued by E. S. Greeley & Co., 5 & 7 Dey Street.

THE CRIST VIBRATORY ENGINE: CATALOGUE. New York; issued by the Crist Engine Company.

SELF-WINDING CLOCKS UNDER THE POND PATENTS: CATALOGUE. New York; issued by the American Manufacturing & Supply Company, No. 10 Dey Street.

GAS. REPORT OF THE JOINT COMMITTEE OF THE CITY COUNCIL AND BOARD OF TRADE OF AKRON, O., ON ILLUMINATING AND FUEL GAS ADAPTED TO HOUSEHOLD, MANUFACTURING, AND INDUSTRIAL USES. New York; issued by T. William Harris & Co., Engineers and Contractors, No. 44 Broadway.

HIGH-SPEED CORLISS STEAM-ENGINES: CATALOGUE. Elmira, N. Y.; B. W. Payne & Sons.

THE BLACKMAN AIR-PROPELLER FOR DRYING: CATALOGUE AND DESCRIPTION. New York; Howard & Morse, No. 45 Fulton Street. UNIVERSAL MILLING MACHINES: CATALOGUE AND DESCRIPTION. Philadelphia; Pedrick & Ayer, No. 1025 Hamilton Street.

ALLEGHENY COUNTY: ITS EARLY HISTORY AND SUBSEQUENT DEVELOPMENT: PUBLISHED UNDER THE AUSPICES OF THE ALLEGHENY COUNTY CENTENNIAL COMMITTEE. Pittsburgh, Pa.; published by Snowden & Peterson. This is the official programme of the centennial celebration of the settlement of Allegheny County, Pa., and contains a history of the county, with notices of its leading industrial establishments.

THE PRINCIPLES OF RAILROAD LOCATION.

By Professor C. D. Jameson.

(*Continued from page* 398.)

CHAPTER XXXII.

RACK-RAILROADS.

The next method used in surmounting great elevations, where ordinary development or the use of switch-backs is impossible either on account of the cost of construction or topographical features, is by means of Rack-Railroads.

In the ordinary railroad the driving-wheel of the locomotive and the rail have each a smooth surface where they come in contact, and the tractive power is due simply to the adhesion between these two smooth surfaces. As has been stated, this adhesion varies with the state of the rail and the wheel, whether moist or dry, etc., and also directly as the weight on the drivers; but it may be taken generally as one-quarter the weight on the drivers. From the resistance due to grade and that opposed to the movement of a train upon a straight and level track, we can at once see that a rate of grade which gives a very slight vertical angle will soon consume all the tractive power of the locomotive. That is, the resistance opposed to the motion of a train upon a grade soon becomes equal to or greater than the adhesion between the rail and the driver.

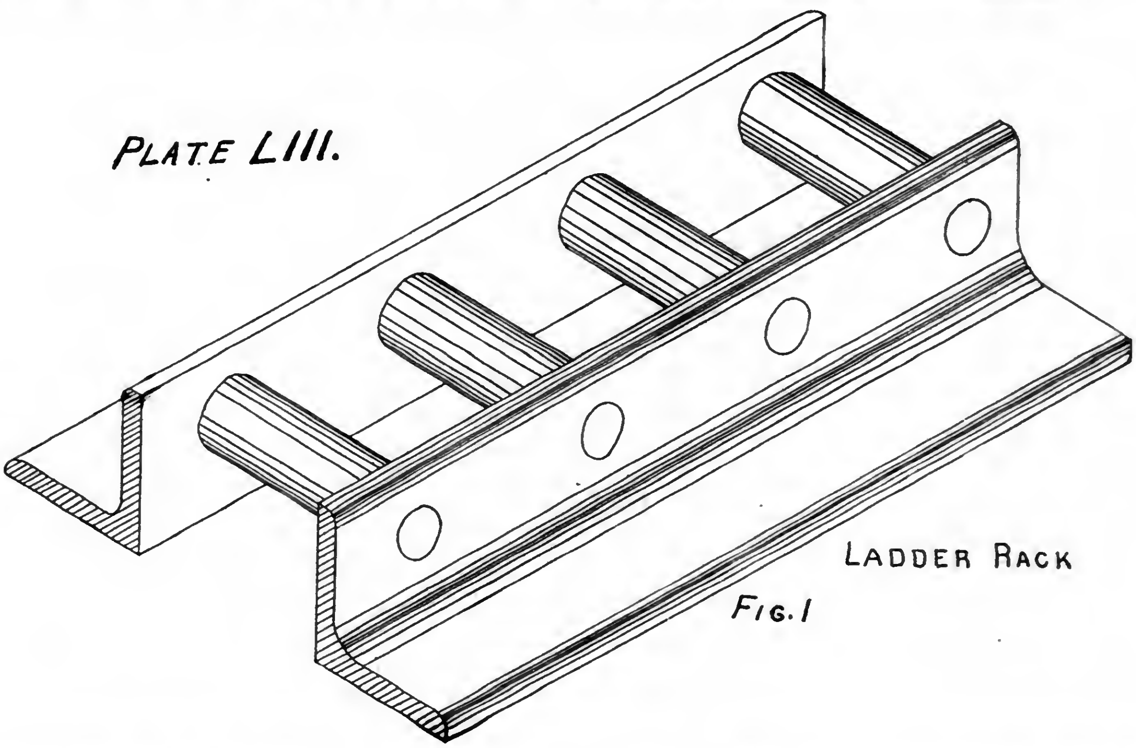
Where circumstances are such that a grade is required so steep that this adhesion between the smooth rail and the driver is insufficient, then there is introduced a rack-rail, as shown in Plate LIII, fig. 1, and Plate LIV, figs. 3 and 4, or a toothed rail, on which runs a pinion or driving-wheel having similar teeth, which engage the teeth on the rack.

By this arrangement the tractive power is not in any way dependent upon the adhesion between the rail and the wheel, but simply upon the steam-generating and cylinder power of the engine. No matter how much power may be exerted, the drivers cannot turn without either a backward or forward motion of the engine. In other words, the drivers cannot slip.

There are various systems of rack-railroads, but they all depend upon this one principle, that the power acts in such a way upon the rail by means of cogs or teeth, as to remove all possibility of slipping.

The most general form is to have the rack-rail a third rail between the two smooth rails upon which the cars run. In this case the toothed drivers on the locomotive are placed in the center one behind the other. Where the grade is very steep, in order to guard against all chances of an accident from a runaway train, there is often a mechanical device so arranged that if the brakes do not act, or if the rack-rail or driver breaks, the whole train can be lifted bodily from the track, resting simply upon shoes, which make it impossible for it to descend.

PLATE LIII.



LADDER RACK

FIG. 1

Owing to the fact that rack-railroads require engines of special construction that are not in any way suited for high speed over ordinary tracks, these roads are not usually made parts of any long line of road, but should be, and in most cases are, simply small independent lines of merely local importance.

Owing to their construction they are not adapted to high speed or to a large business. The first and up to within a few years the only railroad on the rack system in this country was the Mount Washington Railroad, designed and built by Sylvester Marsh.

This system, with some few alterations, was afterward introduced into Europe by Riggenbach, and has since become known as the "Riggenbach System," although, as Riggenbach was well acquainted with Marsh's railroad, and made no changes in the principle, all the credit should be given to Marsh, and not to Riggenbach.

A more modern example of a rack-railroad built upon exactly the same principle as the Mount Washington Railroad is the Green Mountain Railroad at Mount Desert, Me. The length of this road is 6,300 ft., and its rise 1,254 ft. It is made up of a succession of steep grades, with intermediate pieces of easier grades. The maximum

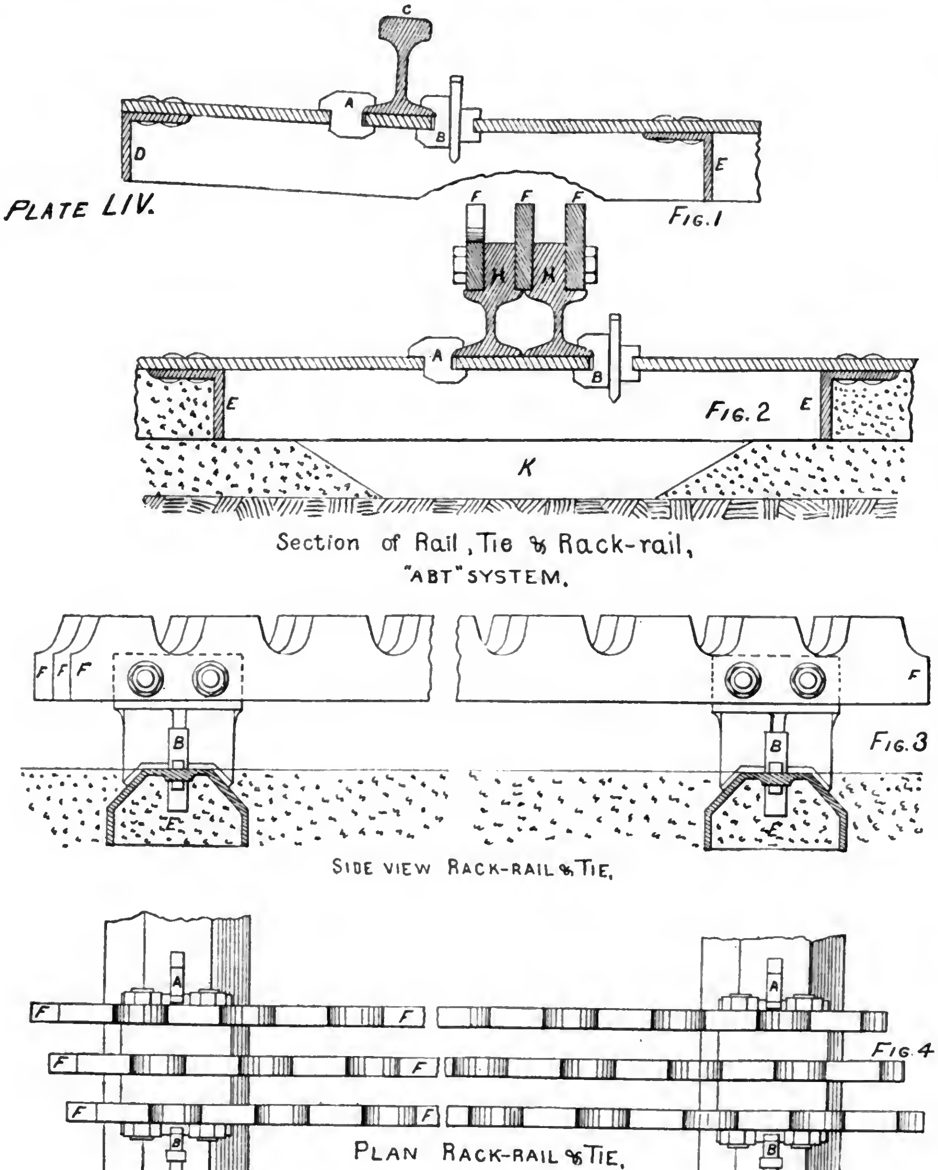
grade is 33⅓ per cent., and the minimum 5 per cent. There is only one curve of 1,910 ft. radius.

The radical difference between this road and the Mount Washington is that the latter is built almost entirely upon trestles, while that at Mount Desert is built upon solid rock or timber cribbing. The rack-rail is of the ladder type, built of angle-irons, as shown in Plate LII, fig. 1. Owing to the steep grade, and the great purchase needed for the driving-gear, the track is built as follows: Where the stringers were laid directly on the natural ledge, this ledge was cleared and leveled; then 1¼-in. holes were drilled every 6 ft. and iron bolts driven through the timber stringers and into these holes. When the stringer came above the ledge bed-ties were introduced under them every 6 ft., these ties being held in place by bolts driven into the ledge on the down grade side of the ties. On top of the stringers are the rail-ties, 6 in. × 6 in. × 6 ft. long, held in place by ⅞-in. bolts driven into the stringer through a groove on the down grade side of the tie. The adhesion rails are of the ordinary **T**-type, weighing 49 lbs. per yard, and held in place by two ordinary spikes in each tie.

The rack is built, as shown in Plate LIII, of two angle-irons, 3 in. × 3 in., placed 4 in. apart in the clear, with 1½-in. round bars, shouldered and riveted between them. The pitch is 4 in. The rack is made in sections 12 ft. long, and held in place by 5½ in. lag-screws, 14 to each section. From this description it will be seen that in no possible way can the track slip down hill.

The rack-rail is placed midway between the smooth rails, and is acted on by a pinion on the locomotive.

The advantage of this road is simply the possibility of introducing grades of almost any degree of steepness, and thus reducing the cost of construction and the length of the lines. The disadvantages, however, are many. Owing to the construction, the speed is limited to about 3½ to 4 miles per hour, and the locomotive cannot be run on an ordinary railroad by adhesion. This limits their use to locations where the rack system can be used entirely.



Another disadvantage is that, owing to the construction of the locomotive and the rack-rail, the introduction of any curves sharper than 3° or 4° is very objectionable.

The system of rack-railroad that up to the present time has given the greatest satisfaction as an operating road, is that invented by Roman Abt, formerly Chief Engineer of the Riggenbach Works in Aarau.

The best examples we have of this system in actual work are the railroad from Blankenburg to Tanna, in the Harz, and the freight road to Oertelsbruch, in Thuringia.

These are combination roads of the adhesion and Abt system. And therein lies the great advantage of that system over all others, that it works perfectly in combination with the ordinary adhesion principle, using the same locomotive for an entire combination line, and only using the rack and pinion where necessary.

The permanent way on these lines is built as follows: The rails are of steel, and of the section shown in Plate LIV, fig. 1; they weigh 60.2 lbs. per yard, and are fastened on iron ties of the Vautherin type by iron keys *A B*, as shown in the drawing. The particular feature in these ties is the two cross-ribs, *E E*, on the inside of the tie, which add so much to its stiffness, and the stability of the road-bed.

The rail-joints come between the ties; the ties are spaced 34.64 in. from center to center. The rack-rail is fastened to the center of the ties by the same system of keying that is used with the adhesion rails, and it has given entire satisfaction. The rack-rail, Plate LIV, figs. 2, 3, and 4, consists of three plates or rectangular bars of Bessemer steel, 0.78 in. thick, 4.33 in. deep, and 8 ft. 7.8 in. long.

These plates are fastened in the steel chairs in such a manner that in every chair there is one joint where the ends of two plates come together, and also two solid plates. At the joints there is a slight space left to allow for expansion. Owing to the thinness of the plates, they can be readily fitted to any required curve. These plates are stepped by each other one-third of the pitch. The pitch is 4.72 in., and the teeth and spaces on the rack are equal.

The two pinions, which are coupled, consist each of three separate disks stepped by each other to correspond with the teeth in the rack, and the arrangement is such that for about every 0.7 in. on the rack a new pinion tooth comes in contact with the rack, and that no less than five teeth of the pinion are engaged at one time.

In order to make this system practicable as a combination rack and adhesion railroad, the locomotive is built with four cylinders, two for working the adhesion drivers and two for the pinions. The two for adhesion work all the time when any tractive power is necessary, and the pinions only to supply the amount of power needed at times in excess of that derived from adhesion.

The rack-rail is only laid, of course, in those parts of the line where it is needed, and where it begins the end is rounded off so as to enable the pinion to mount it and become engaged.

A short section of the rack at each end is connected to the main portion not by a rigid joint, but by a hinge that allows it to move vertically. This portion is supported on springs, and if, when mounted by the pinion, the teeth do not engage, the rack is depressed until the pinion strikes a base plate laid at the height of the bottom of the spaces in the rack. Upon this plate the pinion runs upon its outside circumference, which is greater than the one on which it runs when the teeth are engaged. Consequently, it gains upon the rack, and in a very short distance it has moved ahead enough for the teeth to engage.

By this means all danger of breaking either rack or pinion when passing from an adhesion to a rack section is obviated, and there is no time lost.

Another point to which attention should be called is the manner of putting up the track in regard to the ballast. All the heavy tamping is done under each of the adhesion rails, while no ballast or tamping is put under the tie in the center, this part being left entirely without support, and the ballast on each side forming a ditch.

The object of this lack of support in the center is to allow for any settling of the adhesion rails, and do away with all possibility of springing the tie in any way, and thus changing the relative heights of the rack and adhesion rails.

In both the Abt system and in the old ladder-rack the locomotives are so constructed that when the trains descend with the steam shut off, air is admitted to the cylinders that drive the pinions and makes them serve as air brakes, or, to use a more explicit term, as speed governors.

There is one rack-railroad built where the pinions are placed in a horizontal position with the rack vertical, but it has not proved a success in operation, and there are very few advantages connected with this system.*

CHAPTER XXXIII.

INCLINED PLANES.

The fourth method used for the surmounting of great elevations where the shortest line is obtained without regard to the rate of grade used is by means of INCLINED PLANES.

The different devices used for obtaining the requisite amount of power are as follows:

1. The most simple and also the most economical is that wherein the force of gravity is utilized to its full extent. Inclined planes are often used, so that all the cars that descend are fully loaded, and the majority of the return cars empty. This would be the case where a coal-mine is situated on the side of a mountain, and all the coal had to be dropped into the valley in order to make connection with railroad facilities. In this case the cars used on the incline should be the same ones used in the mine, in order to avoid rehandling the coal at the commencement of the incline.

When a sufficient number of cars are loaded they are coupled together, and the end of a long cable (usually, in these days, of wire) fastened to the last one. This cable passes around a drum at the top of the incline, and the other end is fastened to a train of empty or only partially loaded cars at the foot of the incline. Then, when the loaded cars are started down, their weight pulls up the empties. The speed at which they run is regulated by the drum, the motion of which is controlled by a friction-brake. In this case the force of gravity does all the work.

2. In order, however, to guard against any delays which might occur when it is desired to pull a train up the incline without a sufficient counterweight going down, the drum is connected with a stationary engine, so that power can be taken from that, and a rotary motion given to the drum, thus winding up the cable. In this method, which is the second, the steam-engine simply acts in connection with and as an aid to the force of gravity, which still does the greater part of the work.

In both these cases it is necessary that the incline should be straight and of as uniform a grade as possible. Even when this is the case the great friction of the cable uses up much of the power. Only one train each way can be run at the same time. Only one line of track is needed,

* The Author takes pleasure in acknowledging his indebtedness for some of the data on rack-railroads to Mr. E. E. Russell Tratman.

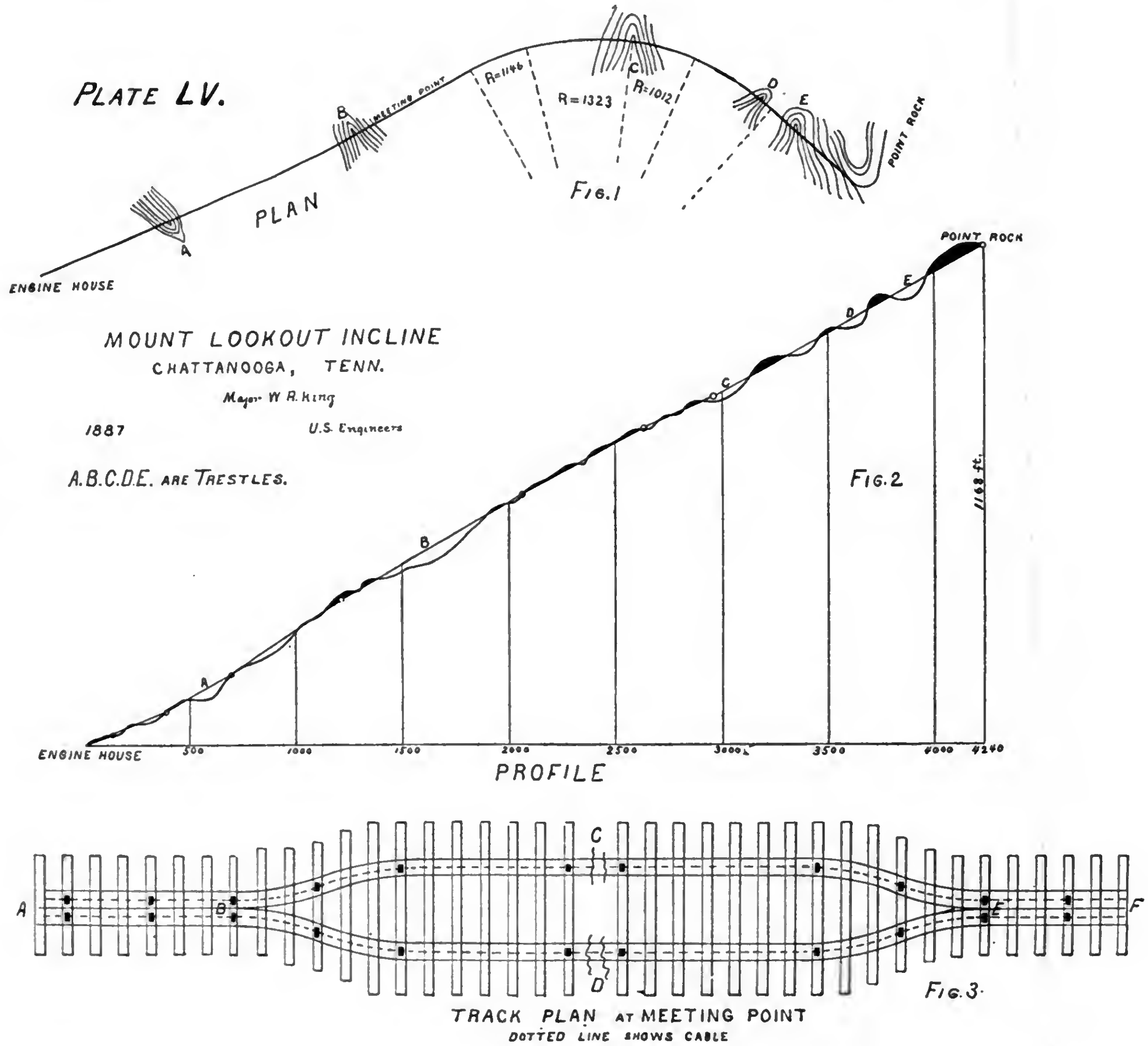
except in the middle, where the trains pass, and the switches should be perfectly automatic—that is, all trains running in the same direction must without fail keep to the same side at the passing point. In Plate LV, fig. 3, let A F be the inclined plane. The dotted line represents the cable; C and D represent the double track for the passing of the trains, and the switches, B and E, must be so constructed that by no possible chance can two trains moving in opposite directions get onto the same track at the passing point.

3. The third method is by use of the stationary engine and cable, without taking into account the force of gravity

In order to operate one of the inclines or roads to its full power, there should be a double track, so that trains should all run in the same direction on the same track.

In the first two methods mentioned of operating inclined planes, the inclines must be nearly straight and of practically uniform grade; for this reason, the possibility of using them is very limited, and this requires special topographical features or great expense. In the cable system, however, this necessity of straightness and uniformity is done away with, and as many curves may be introduced as the nature of the case demands.

The best examples we have of roads (not properly



as giving a possible increase to the power used. In this case the cable is usually of the endless type—that is, the two ends are fastened together. The cable runs around a drum or horizontal wheel at each end of the incline. One of these drums is connected with a stationary engine, and the cable has a sufficient number of turns around it to obviate all chance of slipping. A rotary motion is imparted to the drum, and this gives motion to the cable.

The cars are not attached permanently or to any particular part of the cable, but have a mechanical device called a clutch, by means of which they can take hold or let go of it at any time or place required, and thus stop and start as is necessary.

Provided there is motive power sufficient and sufficient strength in the cable, the only limit to the number of cars that can be run at the same time is the length of the cable.

inclined planes) run by continuous cable are the street railroads of San Francisco and Chicago. In the cable road the cable runs between the rails upon grooved wheels or rollers. In the case of the street railroads, it runs below the surface of the street in a deep groove that has only a narrow opening at the top, just wide enough to allow for the passage of the grip, and not wide enough to permit the entrance of a carriage wheel. The perfection to which each detail of this system of road has been brought makes their use possible and economical in many and varying cases. The latest example we have in this country of an inclined plane is that up Lookout Mountain, at Chattanooga, Tenn.

This incline was designed by and built under the personal supervision of Major W. R. King, U. S. Engineers. Plate LV, figs. 1 and 2, show the plan and profile of the

line. The total length is 4,360 ft., and the elevation attained 1,170 ft., giving a grade of 1 to 3¾.

The system employed is a combination of the balance and hoist principle, one train descending while the other ascends, both fastened to the ends of the same cable, which passes around a grooved pulley or drum at the top of the incline, and the endless cable system.

There are two cables used. The main cable, that runs on top and to which the cars are attached, runs around a pulley at the top, and is the length of the incline, 4,360 ft.

In the ordinary incline, worked upon the balance hoist principle, the stationary engine is at the top of the incline, but in this case this was impossible. The power, from necessity, was at the foot. This led to the use of the secondary cable, which runs under the main cable. This secondary cable is made fast to the ends of the main cable, and passes over a system of sheaves and pulleys at the foot of the incline, which are connected with and driven by a stationary engine.

This makes practically an endless cable, and in the operation the difference between it and the ordinary cable road is that while in the cable road the cable runs always in the same direction, in this the cable runs in one direction for a distance equal to the length of the incline, and then reverses and runs the same distance in an opposite direction.

The cable runs in the center of the track upon grooved pulleys. The track is as shown in Plate LV, fig. 3. There are three rails the entire distance, with the exception of the center point, where the outside rails diverge and the center one splits in two, as shown in the drawing, and thus makes a meeting-point for the trains where they can pass each other.

Three rails were used, in order to do away with all movable parts on the track at the meeting-point, and also from the fact that the greater width gave much more steadiness and solidity to track and road-bed.

Steel rails weighing 25 lbs. per yard were used, with cedar ties 9 ft. long. The rails are fastened down by means of 5-in. lag-screws, having 2 × 3 in. washers, which grip the rail base.

The main cable is 1¼ in. in diameter, composed of six strands of 19 wires each. The secondary cable is 1 in. in diameter, and composed of the same number of wires.

There is a factor of safety of 10 in the main cable, the maximum strain being 5 tons and the breaking strain 50 tons. The cars are built as low as possible, in order to secure greater steadiness. There are a number of novel and ingenious features in order to secure the most perfect safety. Among the most important is that of brakes.

In the first place, they are operated by a spring and by a chain and hand-wheel the same as the old-fashioned car brake, but with this difference, that in order to keep the brakes from working, or to hold the brake-shoe away from the wheel, the hand-wheel must be kept turned up all the time.

During the entire trip the brakeman is obliged to retain his hold on the wheel and keep it twisted. The minute he lets it loose the springs force the brake-shoe against the wheel and the train is stopped.

It is also so arranged that if the cable breaks the brakes are put on whether the brakeman lets go of the wheel or not. Another novel feature is the brake-shoes and their mode of operation. When the brakes are set they are forced under the wheels on the down-grade side, so that the minute the car begins to descend the wheels mount the shoes and are lifted from the track, the whole car resting on the shoes. The part of the shoes that comes against the rail being covered with fine steel points that bite the rail and prevent any slipping.

In order that the conductor may communicate with the engine-house from any part of the line, there is an insulated wire run along near the main cable.

This, with the cable, are connected with the two poles of a battery situated in the engine-house, and by bringing the two in contact a signal is rung in the engine-house. This connection can be made at any time or place from the car by pressing a small knob.

It is so arranged also that if the cable or anything else gives way the alarm is sounded. When the cable is in motion any signal, no matter what, means stop, while it requires a particular and rather elaborate signal to start the engine again.

From the tower of the engine-house, where the engineer has direct and absolute control over the engine, he also has unobstructed view of nearly the whole line. There are only two cars run, one each way, and the road is purely for pleasure travel. The engines used have two 12 × 18 in. cylinders, carry 75 lbs. steam working pressure, and consume about 90 lbs. of bituminous coal per round trip. The time of ascent is 6 minutes, or 8.26 miles per hour.*

(TO BE CONTINUED.)

SECONDARY STRESSES IN FRAMED STRUCTURES.

By I. Hiroi.

By the term *secondary stress* is to be understood that stress in a structure arising from more or less imperfect fulfillment of conditions upon which the first determination of stress (which we will call *primary stress* in contradistinction to the former) was based, as, for instance, the perfect flexibility of joints in framed structures, entire absence of eccentricity at connections, perfect workmanship, etc. That these conditions are not fulfilled in structures as usually built is evident to any one. There is no flexibility of joints in riveted bridges such as are most common in Europe, while in pin-connected ones, as constructed in America, friction between pin and eye is often great enough to produce considerable secondary stress.

Eccentricity at joint exists in most American bridges in lateral connections and in riveted bridges, quite often even in those of main truss members. Secondary stresses, arising from eccentricities at joints, can easily be calculated, and necessary additional section provided in every case for its own if required, and consequently in what follows we shall confine ourselves to the secondary stress arising from stiffness of joints.

American engineers are so well satisfied with their pin-connected bridges that the question of secondary stress has been thus far a subject of very little interest, or rather but little known among many, although the writer remembers having seen some years ago in an engineering journal an article on the subject by a well-known bridge engineer, Mr. Charles Bender.

Evident as it is that the stress calculated under the supposition that every joint is flexible, so that each member without any resistance takes its new position in the strained truss, cannot be the same when there is any cause for such resistance, the secondary stress arising from stiffness of joints has long been more or less in the mind of every engineer; but the first mathematical investigation

* The description of this road is taken from a paper by W. H. Adams, M.E., New York, before the American Institute of Mining Engineers.

of the subject was made by a German engineer, H. Manderla, and made public in the *Allgemeine Bauzeitung* of June, 1880. But his formulæ are rather too complicated for the use of practical engineers. In what follows simpler formulæ of somewhat approximate character will be deduced, and an example worked out to indicate the method of procedure, which gives results accurate enough for all practical purposes when such calculation may be desirable, as in case of rather important structures.

With regard to secondary stresses, the American system of pin connections is evidently superior to that of stiff riveting of most European bridges, but it is true only so long as the secondary moment is greater than the moment of pin friction against rotation. If the latter is greater than the former, then the case is simply that of a stiff riveted bridge. To look more closely into the first step of the discussion, suppose a straight truss be loaded with weights hung at panel points; then every member will be shortened or lengthened according as the stress is compression or tension, and as a consequence the triangles of which the truss consists become deformed, their angles more or less changing, and the total visible result is the deflection of

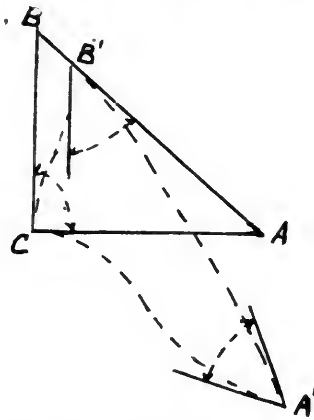


Fig. 1

the truss from its original straight line. But now if the joint be made stiff, either by being riveted or held by friction of the pin, angles cannot change, and as a consequence each member has to deform itself to occupy its new position as shown dotted in the adjoining figure, in which the undeformed triangle $A\ B\ C$ is brought together at C with itself in its deformed state. $B\ C$ has shortened, $B\ A$ and $A\ C$ elongated, and since the angles cannot change, sides become curved, preserving at their ends the included angle equal to the original, or, in other words, the tangents to the elastic line at points C, B', A' form angles exactly equal to angles at C, B, A.

Thus it is evident that under such circumstances bending moments exist in every member. These moments give additional fiber stress which we call the secondary stress due to the stiffness of joints. It is true that when secondary stresses exist, the normal stresses which worked those changes of lengths of members are somewhat less than when none exists, since a part of it is taken up in producing the secondary stress, and as a consequence the position of every panel point in the deformed truss is not exactly the same under both circumstances; but the difference is so small that we can assume without any appreciable error that they are alike, and also that the normal stresses themselves remain unchanged.

The first step in the calculation of the secondary stress is to calculate the changes of angles of every triangle, due to the changes of side-lengths, under the supposition that every joint is perfectly flexible, and then to find out what moments will arise when angles are unchangeable, the side-lengths changing as before. Let A, B, C be three angles of a triangle, and a, b, c the sides opposite them.

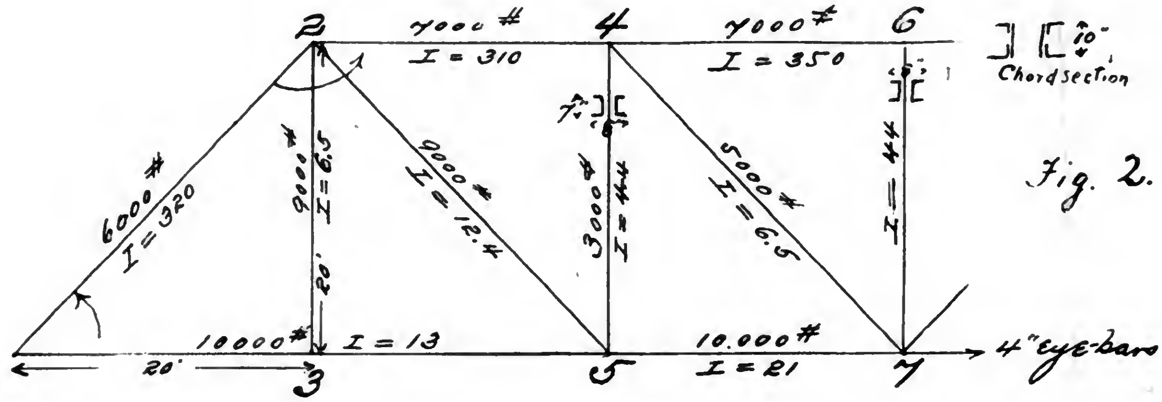


Fig. 2.

We will denote with prefix Δ the amount of deformation of sides and angles. Suppose now the sides a, b, c change by Δa, Δb, Δc, then the simple trigonometrical relations give at once:

$$(b + \Delta b) \sin (A + \Delta A) = (a + \Delta a) \sin (B + \Delta B).$$

Neglecting very small quantities, and transforming we obtain:

$$\Delta A = \left(\frac{\Delta a}{a} - \frac{\Delta b}{b}\right). \tan A + \Delta B. \frac{\tan C}{\tan B}$$

Similarly: $\Delta C = \left(\frac{\Delta c}{c} - \frac{\Delta b}{b}\right). \tan C + \Delta B. \frac{\tan C}{\tan B}$

But $\Delta A + \Delta C + \Delta B = 0$.

Consequently:

$$\Delta B = \frac{\Delta b}{b} (\cot A + \cot C) - \frac{\Delta a}{a} \cot C - \frac{\Delta c}{c} \cot A \quad (1)$$

Symmetry gives:

$$\Delta C = \frac{\Delta c}{c} (\cot A + \cot B) - \frac{\Delta a}{a} \cot B - \frac{\Delta b}{b} \cot A \quad (2)$$

$$\Delta A = \frac{\Delta a}{a} (\cot B + \cot C) - \frac{\Delta b}{b} \cot C - \frac{\Delta c}{c} \cot B \quad (3)$$

With these three equations we can at once determine changes of angles due to changes of sides.

Let us take, for example, a railroad bridge 120 ft. long, consisting of six panels, and 20 ft. deep. Proportioning the bridge for a uniform rolling load of 3,000 lbs. per lineal foot, with the allowed stress of 10,000 lbs. per square inch for tension and 8,000 lbs. for compression, the latter further reduced according to Gordon's formula, we find that under *full* loading (for which case the secondary stress will be calculated) the truss will be subjected to stresses as given in the figure along each member for 1 square in. I is the moment of inertia of the section and given in inches.

All ties are 4-in. eye-bars, and vertical posts 7-in. channels.

Assuming the modulus of elasticity of iron to be 29,000,000 lbs. per square inch throughout, we obtain the following changes of lengths:

$$\Delta 13 = \Delta 35 = \Delta 57 = \frac{10000}{29000000} \times 20 = .000345 \times 20'$$

$\Delta 12 = -.000207 \times \sqrt{800'}$ $\Delta 24 = \Delta 46 = .000241 \times 20'$
$\Delta 23 = .00031 \times 20'$ $\Delta 25 = .000310 \times \sqrt{800'}$
$\Delta 47 = .000172 \times \sqrt{800'}$ $\Delta 45 = -.000103 \times 20'$
$\Delta 67 = 0$

For right-angled isosceles triangles, equations (1), (2) and (3) become

$$\Delta B = \frac{\Delta b}{b} - \frac{\Delta a}{a} \tag{4}$$

$$\Delta C = \frac{\Delta c}{c} - \frac{\Delta a}{a} \tag{5}$$

$$\Delta A = \frac{2.\,\Delta c}{a} - \frac{\Delta b}{b} - \frac{\Delta c}{c} \tag{6}$$

Applying these equations to every triangle of the truss, and substituting the respective side-deformations, we obtain the changes of angles expressed in length of arc :

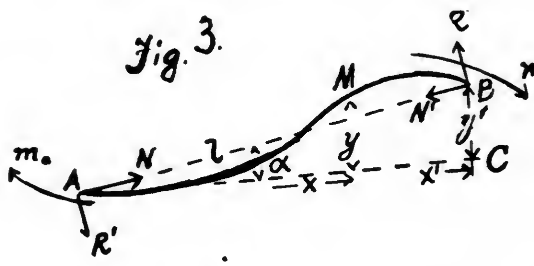
Δ 213 =	.000310 + .000207 = .000517		
Δ 123 =	.000552	Δ 132 =	− .001069
Δ 325 =	.000035	Δ 253 =	0
Δ 235 =	− .000035	Δ 425 =	− .000413
Δ 254 =	− .000551	Δ 245 =	.000964

etc., etc.

We will now proceed to examine the condition of affairs in a single member, when the joints do not allow such changes in angles. Let $A\,B$ be any member, say, a strut. Here it may be remarked that struts are the only members that are influenced by secondary stresses to any extent, as will be seen further on.

Further, let N, N' be normal stresses, which, as already said, may be assumed to be equal to the primary stress of

Fig. 3.



the member. $A\,C$ is the original direction of the strut and tangent to the curve at A ; α , the angle included between two positions of the strut. m_0 and m_1 are the moments acting at and away from A and B ; R and R' the tangential stresses. If the primary stress does not pass through the axis of the member, it may be decomposed at both ends into normal and tangential stresses, N, R ; and the moments changed by the amount of eccentricity multiplied by the force itself. A moment will be called positive when it turns in the same direction as the hand of a watch, and negative when contrary, around any point.

Since stresses in the member are in equilibrium, and as no external force is supposed to be acting on it, it follows from the general equations of equilibrium Σ vertical forces = 0, Σ horizontal forces = 0, Σ moments = 0, that

$$R - R' = 0$$

$$N - N' = 0$$

at B,
$$m_0 - R\,l + m_1 = 0$$

or
$$R = \frac{m_0 + m_1}{l}$$

Let M be the resultant at any point $x\,y$ of moments acting on the left of the point, the co-ordinate axis being taken on $A\,C$, with origin at A ; then

$$m_0 - R\,x - M = 0$$

In this equation the influence of N is omitted, because its effect in producing moment is quite small compared with others, as the bending of a member is under all circumstances entirely inconsiderable.

Substituting the value of R and setting the value of M in the general equation of elastic line, we obtain :

$$m_0 - \frac{m_0 + m_1}{l}\,x = M = E\,I\,\frac{d^2 y}{d\,x^2}$$

in which E is the modulus of elasticity and I the moment of inertia, both of which we will assume to be uniform throughout the member.

Integrating the equation twice, we get :

$$\frac{dy}{dx} = \frac{1}{E\,I}\left(m_0\,x - \frac{m + m_1}{2\,l}\,x^2\right)$$

$$y = \frac{1}{2\,E\,I}\left(m_0\,x^2 - \frac{m_0 + m_1}{3\,l}\,x^3\right) \tag{7}$$

Since α is in any case a very small angle, we can put

$$l = x^1 \text{ and } \alpha = \frac{y^1}{l}$$

In equation (7) putting $x = l, y = y^1$, we obtain :

$$y^1 = \frac{l^2}{6\,E\,I}\left(2\,m_0 - m_1\right)$$

$$\alpha = \frac{y^1}{l} = \frac{l}{6\,E\,I}\left(2\,m_0 - m_1\right) \tag{8}$$

Calling α positive when deflecting to the right and negative when to the left, and designating with subscript

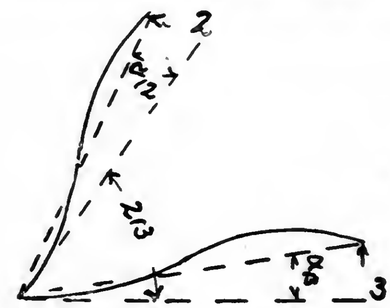


Fig. 4.

the member to which it belongs, we have for any angle 213 the value of its deformation :

$$\Delta\,213 = \alpha_{13} - \alpha_{12}$$

Substituting the value of α in equation (8), with proper subscripts we obtain :

$$6\,E.\,\Delta\,213 = \frac{l_{13}}{I_{13}}\left(2\,m_{13} - m_{31}\right) - \frac{l_{12}}{I_{12}}\left(2\,m_{12} - m_{21}\right) \tag{9}$$

This entirely general equation furnishes as many equations as there are angles. But there are two unknown quantities in each member. The remaining necessary equations come from the condition that for equilibrium the algebraic sum of all the moments must be = 0 at every joint, or $\Sigma\,m = 0$. And in the figure

$$m_{12} + m_{13} = 0 \tag{10}$$

Returning now to our truss, we apply these two equations at every joint and obtain following equations :

At (1)

$$6\,E.\,\Delta\,213 = .000517 \times 6\,E = 87958$$

$$87958 = \frac{240}{13}\left(2\,m_{13} - m_{31}\right) - \frac{340}{320}\left(2\,m_{12} - m_{21}\right)$$

$$m_{12} + m_{13} = 0$$

at (2)

$$-\,71.862 = \frac{340}{12.4}\left(2\,m_{25} - m_{52}\right) - \frac{240}{310}\left(2\,m_{24} - m_{42}\right)$$

$$6090 = \frac{240}{6.5}\left(2\,m_{23} - m_{32}\right) - \frac{340}{12.4}\left(2\,m_{25} - m_{52}\right)$$

$$96048 = \frac{340}{320}\left(2\,m_{21} - m_{12}\right) - \frac{240}{6.5}\left(2\,m_{22} - m_{32}\right)$$

$$m_{24} + m_{25} + m_{23} + m_{21} = 0$$

at (3)

$$-\,186006 = \frac{240}{6.5}\left(2\,m_{32} - m_{23}\right) - \frac{240}{13}\left(2\,m_{31} - m_{13}\right)$$

$$6090 = \frac{240}{13}\left(2\,m_{35} - m_{53}\right) - \frac{240}{6.5}\left(2\,m_{32} - m_{23}\right)$$

$$m_{31} + m_{32} + m_{35} = 0$$

etc., etc., etc.

The direction in which we have taken α as positive and negative should be remembered, and so applied at every angle. Since the loading is symmetrical, it is evident that there exists no secondary stress in member 47, what comes from one side being neutralized by equal moment from the other.

Solving the above equations, we obtain values of several m's in inch-pounds :

$$
\begin{array}{lll}
m_{12} = -\ 4400 & m_{13} = +\ 4400 & \\
m_{24} = +\ 8000 & m_{25} = -\ 1500 & m_{23} = -\ 2500 \\
m_{35} = -\ 2100 & m_{32} = -\ 2500 & m_{31} = \ \ 4600 \\
m_{42} = +\ 49000 & m_{45} = -\ 10000 & m_{47} = -\ 1000 \\
m_{45} = \ \ 40000 & &
\end{array}
$$

etc., etc.

The deformations when exaggerated give a form to the truss, as in the figure:

quently the effect of the secondary moment is very small. It is the compression members that are greatly influenced by the secondary moment. The normal stress, N, which we have omitted in the equation of the moment, while it tends to counteract in case of tension members any end moments, in compression ones helps to bend more and more. It must be remembered that the truss we have taken as an example is a kind comparatively free from secondary stress. In Warren girders it is not unusual that a stress of more than 100 per cent. of primary stress is found in some of its parts.

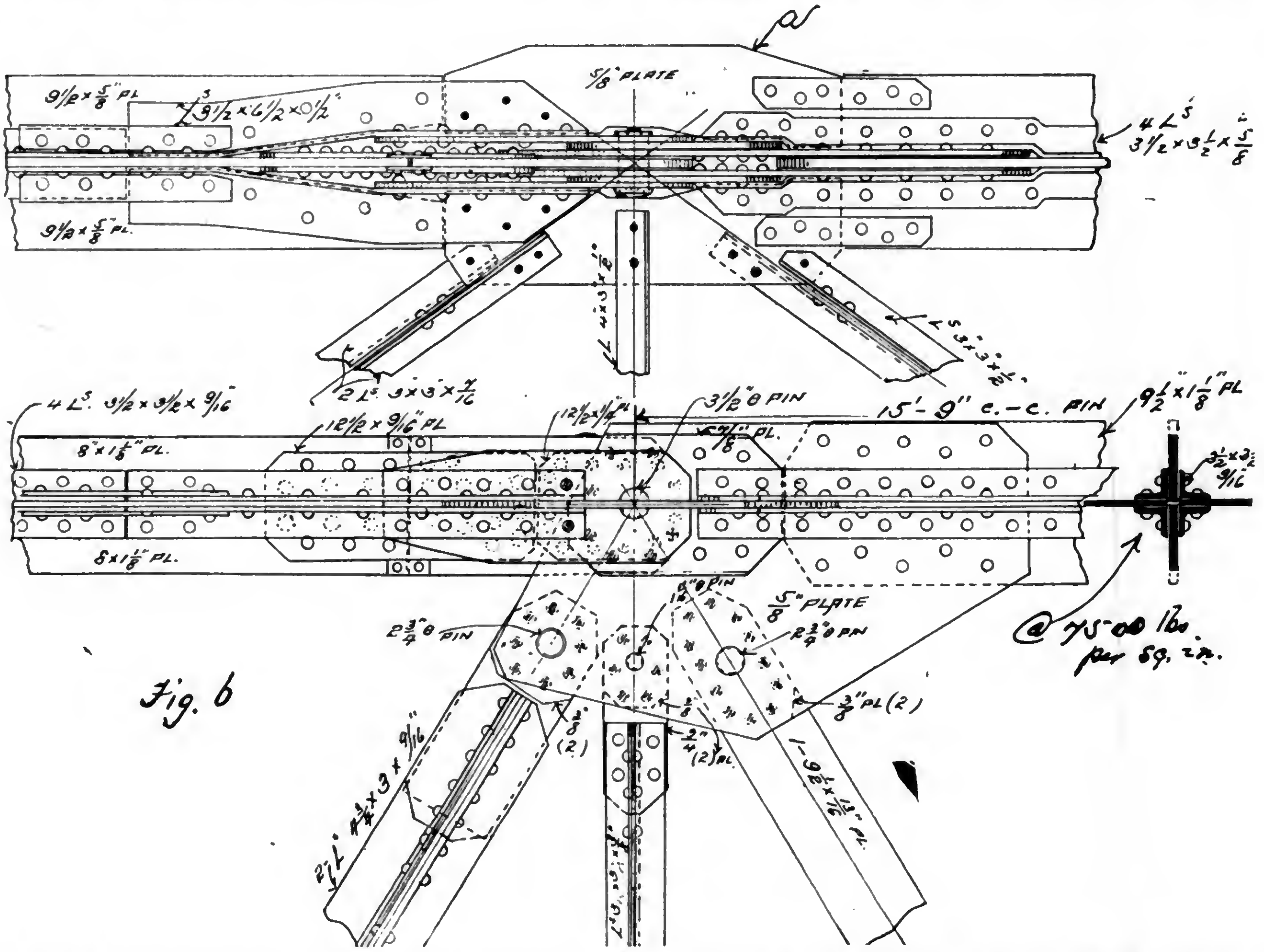


Fig. 6

From these moments it is now a simple matter to calculate fiber stresses, having the moments of inertia and the distances of furthest fibers of every member. Thus we have :

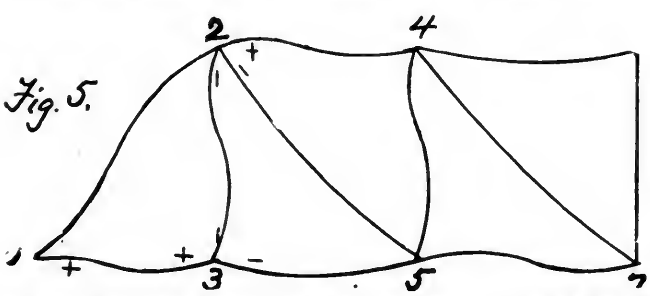


Fig. 5.

in 24 near 4 $\frac{49000}{310} \times 5 = 800 \pm$ per sq. in. $= 11\frac{1}{3}\%$ primary stress

" 46 " 6 $\frac{40000}{350} \times 5 = 580$ " $= 8\%$ " "

" 45 " 4 $\frac{10000}{44} \times 4 = 910$ " $= 15\%$ " "

etc., etc.

The secondary stresses in tension members are quite small, except once in the hanger near (3), where it amounts to 8 per cent. Eye-bars possess, however, near their ends much greater moment of inertia than in the body, consequently the effect of the secondary moment is very small.

Returning once more to our fundamental equation (8), we see that the greater the moment m_0 the greater will be the departure $\propto$; consequently, the worst case arises where two compression members are closed by a tension member, as the specific change of length in the latter is always greater than in the former. This fact is to be observed in moments m_{64} and m_{52}. Tensile members, when they possess but small amounts of moment of inertia, by which great bending moment cannot exist without bending the bar to a considerable extent which, in turn, is not possible on account of the great normal stress, are favorable to stiff compression members with which they meet, as at every point the algebraic sum of moments must be $= 0$. Too wide eye-bars should not be used, not only because they are stiff, but also because they necessitate the use of pins of proportionally great diameter, which becomes the cause of great frictional resistance.

Further, in that equation we find that for the given value of y, the greater l is, the smaller will be the value of $\propto$; hence long panels and deep truss will tend to reduce the secondary stress.

At the moment the scaffolding is removed from under the structure, it may be supposed that every member has taken its proper position in the strained truss, so that there exists no secondary stress. Under such circumstances it is evident that the secondary stress is to be expected only from the *moving load*.

Now, coming to pin connections, it is merely necessary to find out the amount of frictional resistance, and com-

pare it with the secondary moment at that place. Since we are not certain as to the coefficient of friction, especially under such high pressures, it is hardly of use to enter into the elaborate calculation. Take, for example, joint 2. Allowing 15,000 lbs. per square inch for fiber stress on the pin, and taking everything into consideration, a 4-in. diameter-pin will not be found to be too large. If we assume the coefficient of friction to be 0.3, we find the frictional resistance of the pin against the motion of chord 24 to be about

$$160000 \times .3 \times 2 \text{ in.} = 96000 \text{ inch-pounds,}$$

which is more than 10 times the secondary moment. It may be well to rivet up such joint to protect the pin, at least, from torsional stress, as it is a stiff joint after all. As to the rest of the chord-joints, they are all stiff joints, as in all American bridges they are spliced to the extent of from 25 to 100 per cent. of chord sections, according to specifications. The only movable members are webs. At joint 4 the diameter of pin will be, with the allowed pressure of 12,000 lbs., equal to $\frac{40000}{12000} = 3\frac{3}{8}$ in. This offers to the post the resistance of

$$20,000 \times .3 \times \frac{27}{16} = 10,100 \text{ inch-pounds,}$$

which is little more than the secondary moment at that place.

Comparing in this way, it will be found that in most American bridges the friction of pins is much greater than the secondary stress, so that they assume the character of riveted bridges.

It is interesting to observe how in some German bridges (namely, those built by the South German Bridge Company, according to the patent system of Gerber) joints are so designed as to reduce secondary stress to the smallest possible amount by using several pins. The adjoining sketch shows a top-chord joint of the bridge over the Main near Wertheim, with a span of 220 ft. The largest pin in the whole structure has a diameter of $3\frac{1}{2}$ in. Every member turns upon its *own* pin—an arrangement entirely different from several members having a common pin, whose size naturally depends upon the resultant action of all the stresses. Thus the vertical has a pin $1\frac{1}{16}$ in. in diameter, having but about $\frac{7}{8}$ in. leverage for frictional moment. A somewhat large amount of secondary stress in top-chord is still unavoidable, but by such arrangement it is kept down to a very small percentage of the primary stress. Plates *a*, which easily bend in vertical plane, give all the lateral stiffness that is desired, while helping to transmit a part of the stress from one section to another. There is no eccentricity in connections of either main or lateral connections, and the whole skeleton allows a very exact calculation of stresses in members.

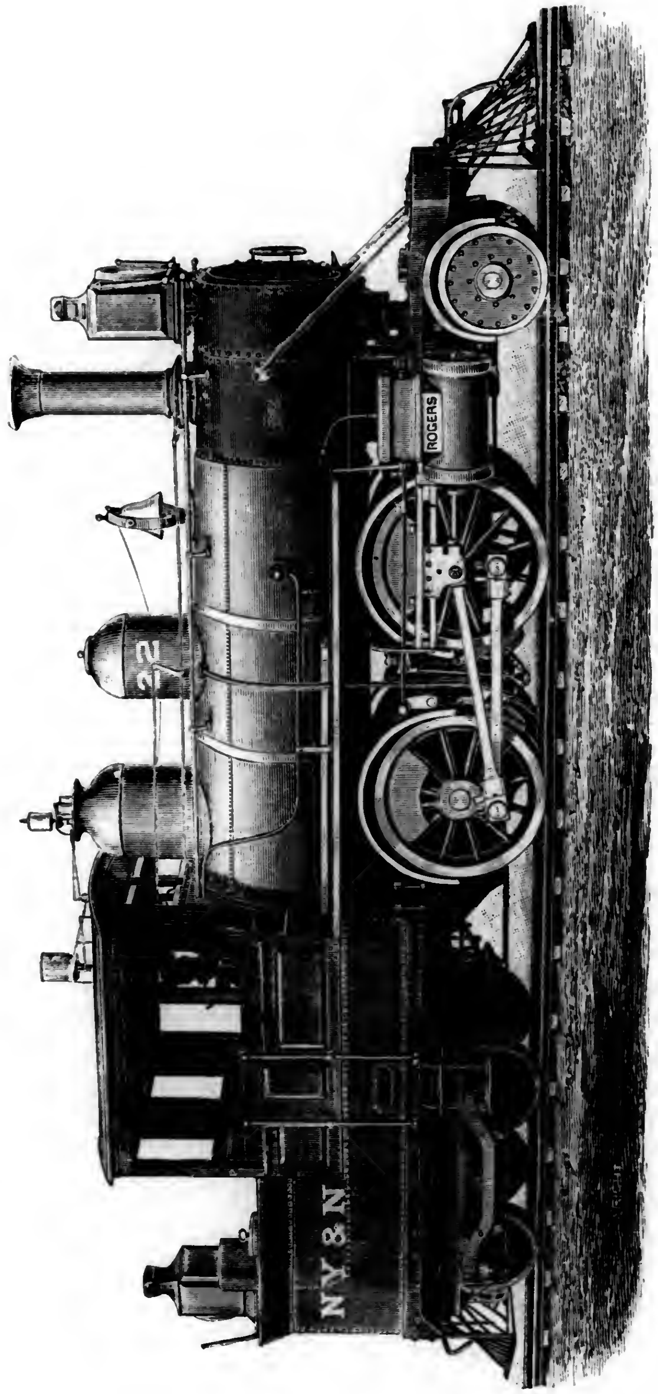
Such a construction, however, merely shows how secondary stresses can be reduced, and is hardly practicable in the competitive works of American bridge-building, which require greater simplicity and more economical sections.

Effect of High Explosives on the Design of Warships.

(Abstract of paper read before the Institution of Naval Architects at Glasgow, Scotland, by Captain Fitz Gerald.)

THE data which I have been able to collect with reference to my subject is so extremely meager, that I feel almost ashamed to bring it before this Institution in its present stage; and my only excuse for doing so is the great interest and importance which attaches to it, and the urgency, if I may so express it, of the subject of high explosives used in shell fired from regular powder guns, not pneumatic tubes. I am also in hopes that some of our naval architects may have been prying into the future by watching experiments and collecting information, and that they, perhaps, may be able to throw more light on the subject than I can do, and that the discussion which I hope will take place, will, at any rate, cause us to realize that we are face to face with a new method of attack, which may very possibly call for some modifications in ship designs for war purposes. In spite of the cloud of secrecy which our neighbors have endeavored to cast about the subject, we have been aware for some time back that they have been making experiments with a high explosive called melenite, a species of blasting gelatine, which, I am informed, is poured liquid into the shell, and then allowed to solidify. The explosive force of melenite is about equal to gun-cotton, weight for weight, but volume for volume it is much greater; that is to say, melenite is heavier, so that in a given space, say the interior of a shell, you can put half as much again of melenite as gun-cotton. The difficulty of using high explosives in shell has hitherto been the liability of the concussion of the gun causing the shell to burst in the bore, and thus to destroy the gun. How this difficulty has been overcome, I am not in a position to tell you; but that it has been overcome in the case of melenite we are very well assured, as numerous experiments have been carried out with it. As to the more sudden and destructive effect of what are called the high explosives, as compared with gunpowder, you are, no doubt, all aware. An ordinary gunpowder shell fitted with a percussion fuse, when it struck the thin side of a ship which it was capable of penetrating, passed several feet onward before it exploded; but shells fitted with high explosives are said to burst actually on contact, or when the shell is passing through the thin side, so that the destruction caused is out of all proportion to the gunpowder shell, many square yards of the side being actually blown away, or, as it was graphically described to me, nothing left but daylight. On the other hand, it is somewhat cheering to hear that there is an antidote, and that very moderate armor is capable of breaking up these high explosive shells, and rendering them comparatively harmless. Thus it is stated that steel armor 4 in. thick is capable of breaking up the melenite shell from the French 16 centimeter gun—a gun about equal in power to our 6-in. gun. If this is really the case there is something hopeful in the prospect for this country, as it points to an important future for our numerous so-called obsolete thin-armored ships. They are iron built, and although they lack many of the best features of modern ships, such as numerous compartments, double screws, under-water steering gear, etc., they would seem to be worth re-engining and re-arming, not with two or three heavy guns, but with numerous light, quick-firing ones, firing high explosives. They would, I believe, prove formidable fighting machines against any partially armored ships. It is stated that the new French cruiser, *Dupuy-de-Lome*, of 4,000 tons, and a speed of 19 knots, is to be plated with 4-in. steel armor, for the purpose of breaking up high explosive shell, though she appears in Lloyd's "Warships of the World" as only a deck-protected cruiser. It is also stated that the French are plating their cofferdams with a similar object. This would be internal armor with a vengeance. But I only give you the report on hearsay evidence.

It seems to me that we are working round in a circle in this question of guns and armor; and the introduction of quick-firing guns of 6-in. caliber, and the very probable introduction of high explosives in shell, will, I think, necessitate a return to moderate armor and lighter armaments altogether; with, possibly, the abandonment of very heavy guns afloat, as not being worth their weight and trouble, when the slowness of their fire is taken into consideration. The almost complete sacrifice of a ship of 10,000 tons to the carrying of two or three heavy guns seems to be a miscalculation of the chances of hitting from a moving platform—for gunners, after all, even behind armor, are only human beings, and liable to make mistakes; and it seems likely that the introduction of high explosives in shell of moderate caliber will help to bring us back again to some modification of the type of our earlier ironclads, so as to insure us against the greater number of chances; for we must ever bear in mind that it is simply a question of chances. There is no absolute safety, nor anything approaching to it, in any design of warship; and the recent practice of reducing greatly the extent of armor, for the purpose of thickening it in places, has exposed large areas as happy hunting-grounds for high explosive shell of small caliber. Almost all modern ships have many such places which they cannot afford to



LOCOMOTIVE FOR SUBURBAN PASSENGER SERVICE.

BUILT BY THE ROGERS LOCOMOTIVE AND MACHINE WORKS, PATERSON, N. J.

see destroyed with impunity. I should like to know, for instance, how these huge Italian ships, with hardly any armor—ships which some of our naval architects so greatly admire—will get on when their sides in the region of their water-lines are attacked with explosive shell, and large areas of them blown away. I should imagine that they would get a heavy list, if, indeed, the righting-lever does not disappear altogether, and I cannot see that the weight of armor expended in their submerged decks will be of much value to them. It will be seen that my remarks are merely intended to be suggestive. I have made no attempt to dogmatize on the subject of high explosives. The question is in an untried and speculative stage, and my only object is to draw attention to it, and to urge our naval architects to watch closely the experiments which are about to take place with the *Resistance* in this connection; and I sincerely hope that there will be no hollow pretense at secrecy about these experiments, for the only result of such tactics will be to hide useful information for a certain time from our own naval architects, while foreigners will certainly obtain all they require.

Passenger Locomotive for Suburban Service.

THE accompanying illustration represents an engine built by the Rogers Locomotive Works, Paterson, N. J., for the New York & Northern Railroad, and intended to work short suburban trains on that road, where a locomotive is needed which will start quickly after each of the many stops required, and which will waste no time at terminal stations. In some respects it differs considerably from other engines built for a similar purpose.

As shown by the engraving, which is made from a photograph of the engine, the tank is carried upon the frame. There are four drivers, with a four-wheeled truck under the tank end and a two-wheeled or pony truck forward of the cylinders.

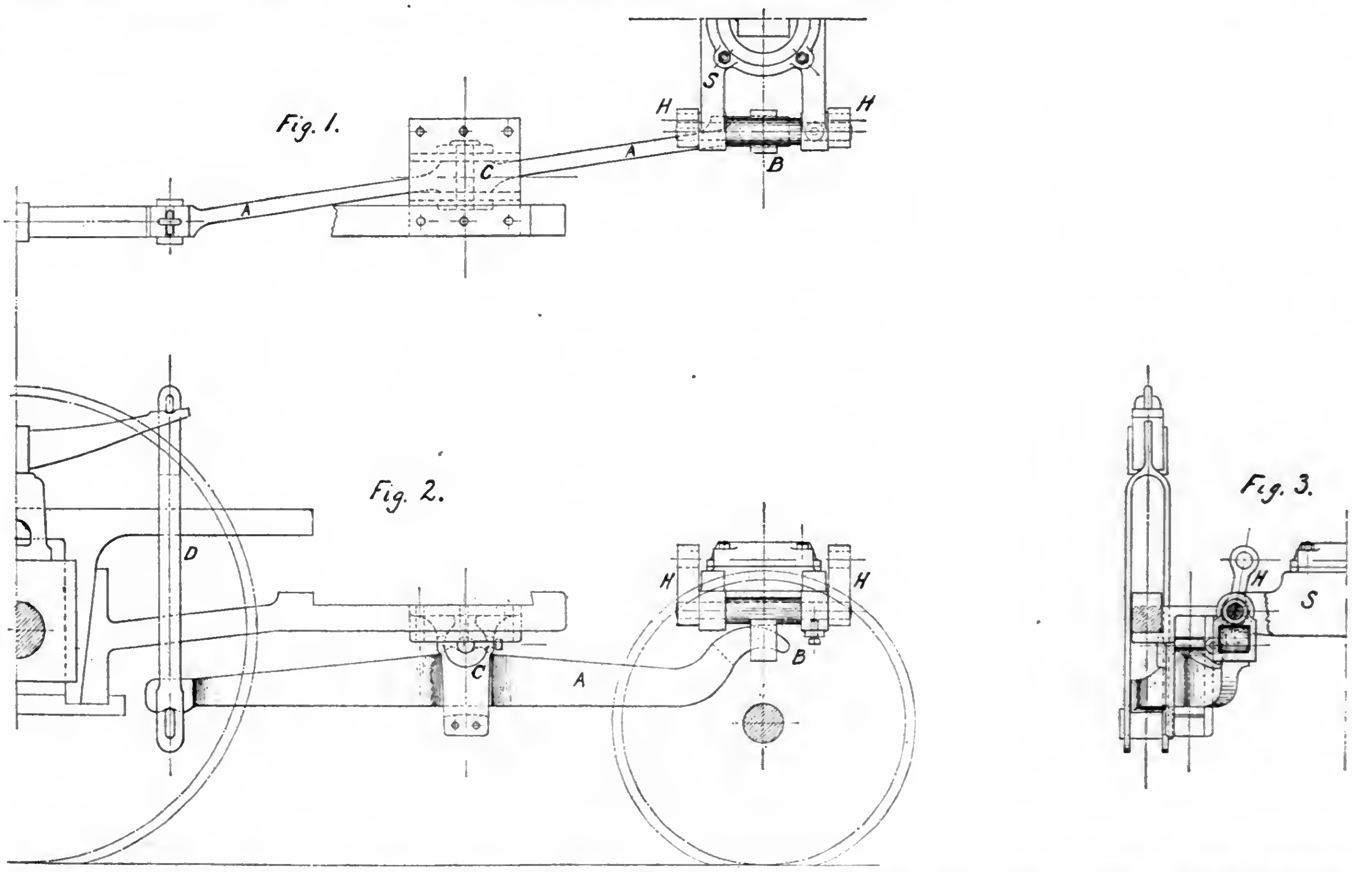
The principal dimensions of these engines are as follows:

Gauge of road	4 ft. 8½ in.
Diameter of cylinders	14 in.
Stroke of cylinders	22 in.
Diameter of driving wheels	54 in.
Rigid wheel-base	6 ft. 3 in.
Total wheel-base	27 ft.
Diameter of boiler barrel at smoke-box end	52 in.
Length of flues	7 ft. 10¾ in.
Diameter of flues	1¾ in.
Length of fire-box	71½ in.
Width of fire-box	41 in.
Height of fire-box, front end	47 in.
Height of fire-box, back end	43 in.
Grate area	20 4 sq. ft.
Total weight of engine	98,500 lbs.
Weight on drivers	50,000 lbs.

These engines have a water-grate and burn anthracite coal. The capacity of the tank is 1,000 gallons of water, and three tons of coal can be carried. The legs of the tank extend forward on each side of the fire-box in front of the cab, and from the frame up the running-board; a pocket is formed in the side for a step, as shown in the illustration. The water-space is made higher at the back in order to give additional room and to provide a convenient place for the man-hole. The total length of the tank over all is 14 ft. and its outside width 8 ft. 6 in.

The engine is equipped with the Eames brake applied to the drivers and to the truck under the tank end.

The four-wheeled truck under the tank is a center-bearing swing-motion truck having a solid rectangular wrought-iron frame, with equalizing bars, etc., its construction not differing materially from the ordinary truck, as can be seen from the engraving.



A sketch of the two-wheeled truck is given herewith, fig. 1 being a half plan, fig. 2 an elevation, and fig. 3 a half cross-section. The drivers have an equalizing lever between them as usual, but the forward hanger of the forward driving springs extends down on each side below the frame and carries the end of an equalizing bar *A*, the other end of which extends to the swing-hanger of the truck, forming a lever, the fulcrum of which is a pin carried by the frame underneath the cylinder saddle at *C*. The forward end of this lever is connected with the truck by stirrups *B B*, which are carried on the hanger-pins of the truck between the arms of the spring bolster or cradle; as this cradle has no lateral motion, the stirrups *B B* have

also no lateral motion, and the equalizing levers *A A* retain the same position in relation to the main frame of the engine as to lateral movement. The arrangement will be readily seen from the drawings. The pin at the center of the equalizing lever of the truck could as well be made at right angles with the center line or the bar, but in this engine it was made at right angles to the frame simply to avoid the necessity of making right and left-hand patterns for the casting which holds it, the equalizing bars being forged in the proper shape to suit it. This arrangement of truck and equalizer has proved in practice strong and durable; it also makes a very neat job, and is apparently preferable to the somewhat unsightly arrangement of levers over the frame and back of the smoke-box, which is often used in similar cases.

The general design of the engine, especially that of the truck and equalizers, is due to Mr. Reuben Wells, Superintendent of the Rogers Works.

These are certainly very neat, compact, and serviceable-looking engines, and have so far given satisfaction in a very trying service.

UNITED STATES NAVAL PROGRESS.

We give below some extracts of current interest from the notes on ships and torpedoes in the latest number of *Naval Intelligence*, issued by the Bureau of Navigation of the Navy Department.

THE ARMORED BATTLE-SHIP "TEXAS."

The battle-ship *Texas* is to be built at the Norfolk Navy-Yard on designs by Mr. W. John, General Manager of late Barrow Shipbuilding Company.

The main battery consists of two 12-in. breech-loading and six 6-in. breech-loading guns. The former are in turrets placed *en echelon*, the port one forward and the starboard one aft. The train of port gun is 180° on port side, and from abeam to 40° forward on starboard side; the after one trains 180° on starboard, and 70° on port side. Two of the 6-in. guns are on the upper deck, one forward, one aft, near the 12-in. guns, and each trains through 240°; the others are in sponsons on the lower deck, two each side, with firing arcs of 115°. The secondary battery is composed of four 6-pounder and 3-pounder rapid fire guns, four 47-mm. and four 37-mm. revolving cannon, and two Gatlings. Four torpedo-launching tubes will be fitted.

The estimated speed is 17 knots, and the I. H. P., with forced draft, 8,600. The engines, driving twin screws, are triple-expansion; diameters of cylinders, 36, 51, and 78 in; length of stroke, 39 in. Steam is taken from four double-ended boilers, 17 ft. long, and having a diameter of 14 ft.

The normal coal allowance is 500 tons; 950 can be carried, giving a radius of efficiency of 3,137 nautical miles at a speed of 15.2 knots, 4,500 at 13.3 knots, and 8,592 at 10 knots.

For defense the vessel has a water-line belt of 12-in. steel armor in wake of magazines, engines, and boilers. The ends are connected by athwartship 6-in. steel bulkheads. An armored redoubt runs diagonally across on main deck, enclosing and protecting bases of turrets and their machinery; this as well as the turret armor is 12-in. steel. The conning-tower has the same protection. The ammunition tubes have 6-in., and tube from conning-tower down to protective-deck, 3-in. steel protection. The protective-deck, 3 in. thick, covers the armor belt and curves down forward and abaft it to stem and stern. Coal bunkers are outboard of, and above boiler and engine-rooms.

Between the starboard and port fire-rooms are magazines and shell-rooms, with a fore-and-aft passage above them communicating with additional ammunition spaces forward of fire-room and abaft engines.

The displacement, at normal draft of 22 ft. forward and 23 ft. aft, is 6,300 tons; with 950 tons of coal on board, it is 6,750 tons.

The length between perpendiculars is 290 ft., and extreme beam, 61 ft. 1 in.

The *Texas* is to be built of steel. She will have a double bottom and numerous water-tight compartments; there are to be two masts with military tops; electric search-lights are to be placed on hurricane deck and chart-house. The estimated cost, exclusive of armament, is $2,376,000.

TORPEDO-BOATS.

The naval maneuvers of 1887 abroad confirmed the opinion formed in 1886 that torpedo-boats of small tonnage are not adapted for service at sea, and that their field of operations is restricted to operations on or near the coast and in harbors. The tendency at present is to build boats exceeding 130 ft. in length, with displacements ranging above 90 tons, carrying machine and rapid-fire guns in addition to the torpedo armament.

European powers have begun but a comparatively small number of torpedo-boats during the present year, although a large number have been added to the strength of the fleets; but these have, in a majority of cases, been completed in fulfilment of old contracts.

In general, it may be fairly said that the smaller type of torpedo-boat, so highly thought of in 1885, has lost much of its prestige.

The principal sources of weakness in the smaller boats have been found to lie in inefficient boilers and light construction of hull. A new boiler, invented by Messrs. Thornycroft & Company, has been largely adopted, and is giving very satisfactory results; and the tendency to work more material into the construction of the hull and protection of vital parts bids fair to overcome the second weakness noticeable in the earlier boats, in which so much was sacrificed for speed.

The necessity of torpedo repair and supply vessels again made itself apparent during the naval maneuvers. In England a large and powerful vessel, the *Vulcan*, is building, and in Italy two vessels of this class are to be built. The Germans have appreciated the value of this class of vessel for some years, and have constructed division torpedo-boats. These vessels are fitted with complete workshops and spare stores, and are intended to accompany divisions of torpedo-boats.

The difference of the speed of torpedo-boats on trial and in actual service, almost always considerable, was well illustrated in the races of the English torpedo flotilla in the Channel, in which the victor attained a mean speed of but 16.25 knots per hour for five hours, while on the original measured mile it realized a speed of 21 knots. This was also illustrated in the competitive trials of Russian torpedo-boats of various types in the Baltic in September last, the loss of speed amounting to 2½ to 4 knots in boats but a year old. The single exception known to this rule is that of the Normand boat *Sveaborg*, which realized in this trial its original trial speed.

The trials of the Nordenfelt submarine torpedo-boats in England and Turkey have attracted considerable attention, and mark a new phase in torpedo warfare. Their present under-water speed of 4 or 5 knots is very low for efficient service against ships under way; but the attention of inventors and naval constructors is now directed to this type of boat, and doubtless it will be largely developed in the future. In a circular recently issued by the Navy Department calling for proposals for a submarine torpedo-boat an under-water speed of 8 knots is deemed requisite. This circular probably indicates the most advanced thought and opinion in regard to submarine boats.

The *Stiletto* had her final official trials in Narragansett Bay, on August 20, 1887. The trials consisted of a three hours' run over a measured distance. The weather was very favorable, sea smooth, and no wind. The total weight carried was 9 tons, 640 pounds, which included 4 tons, 540 pounds of coal. The displacement with this load was 31 tons. Draft of water before trial, forward, 2 ft. 9 in.; aft, 2 ft. 10 in. After the trial the draft forward was 2 ft. 7 in., and aft, 2 ft. 8 in. The mean speed for the three hours' run was 18.22 knots. The vibration at high speed was moderate. A navy compass was quite steady wherever placed. The mean I. H. P. developed by the engines was 359. The endurance with 5 tons of coal is computed at 507 miles at a speed of 11 knots.

The *Stiletto* was bought by the U. S. Government for $25,000, and turned over to the Torpedo Station, on May 28, 1888.

Messrs. Herreshoff, of Bristol, R. I., have signed a contract, March 1, 1888, to build for the U. S. Navy a deep-sea twin screw torpedo-boat, exclusive of torpedoes and their appendages, for $82,750, of the following dimensions: Length over all, 138 ft.; length on deck, 134 ft.; extreme breadth, 15 ft.; extreme depth, keel to crown of deck amidships, 10 ft. The keel will be rocker-shaped, the draft aft, 4 ft. 8 in. The displacement will be about 100 tons, and the H.P. is estimated at 1,600. The engines are to be five-cylinder quadruple expansion, driving twin screws. The two boilers are to be of Herreshoff's latest design, and placed in separate compartments forward and abaft the engine-room. Eight bilge-ejectors will give a total discharge of 280 tons per hour. A steam steering engine will be fitted to work a balance rudder of large area. The engines and boilers will be protected by coal. The interior will be divided into 11 water-tight compartments and lighted by electricity. There will be two conning-towers, one forward and one aft, with a search-light on each. The armament is to consist of two bow torpedo tubes, a torpedo gun aft, and three 37-pounder rapid-firing guns.

A weight of 15 tons is to be carried on trial, which will be a three hours' continuous run. If on a three hours' trial the mean speed of the boat exceeds 22 knots, a premium of $1,500 will be paid, provided the boat is accepted by the Department, for each quarter of a knot in excess of 23 knots, and $2,000 for each quarter of a knot in excess of 24 knots. If the speed of the three hours' trial calculated as aforesaid falls below 22 knots a penalty of $4,000 will be exacted. If the speed on trial falls below 20 knots, the Department reserves the right to reject the boat. The contract calls for the completion of the boat in 15 months.

Covered Reservoirs.

(Abstract of paper in the *Journal* of the New England Water-Works Association, by Charles H. Swan, Boston.)

COVERED reservoirs have been used for the storage of water from periods of great antiquity. They have been constructed of various sizes and shapes, from the small cisterns supplying single dwellings, to the large reservoirs of ancient fortified cities, and of modern municipal water works.

During recent excavations at Jerusalem, many ancient reservoirs have been discovered. Those which appear to be the oldest, and of very great antiquity, were formed by sinking deep wells through the rock and then making an enlargement at the bottom to act as a collector. Second in antiquity are the cisterns with natural roofs. These were excavated in a stratum of softer rock, the overlying harder stratum serving as a roof. A third class was formed by excavating the rock and covering the opening with an arch. A fourth class, modern, were built amid the loose débris, the accumulations of the centuries, which forms a large portion of the site of the modern city. It is estimated that the ancient subterranean cisterns in the vicinity of the Temple alone contained upward of 10,000,000 gallons. One of them, known as the Great Sea, is said to have had a capacity of 2,000,000 gallons. Numerous other cisterns, some of them of large capacity, have been discovered, excavated in the rocky hills of the vicinity.

Many fortified cities of antiquity were provided with subterranean reservoirs to supply water during sieges. The ancient cisterns of Constantinople are reported to have contained a supply for 1,000,000 men during four months. Several of them are still in existence. Other ancient covered reservoirs might be mentioned, but these examples are sufficient to indicate their magnitude and importance.

The covered reservoirs of modern water-works owe their origin to the necessity for maintaining the purity of the supply when it is stored in the vicinity of large cities. The effect of covering is:

1. To protect the water from solar heat and light; thereby securing uniformity of temperature and preventing the growth of vegetation.
2. To protect the water from atmospheric impurities.
3. To prevent malicious pollution.

These three classes of evils vary in relative importance in different climates and localities.

It has for many years been recognized that water derived from certain subterranean sources is peculiarly liable to be invaded by vegetable growths upon exposure to the light and heat of the sun in open reservoirs. Examples of this action have been found in water from various geological formations, both in Europe and in the United States. Apparently, such water contains principles which do not affect its clearness or limpidity, but which promote vegetation upon exposure to the light, rendering the water unsightly, and frequently developing a disagreeable taste and odor. The examinations of the water supplies of towns now being made by the Massachusetts State Board of Health will, it is hoped, furnish an explanation of this curious fact.

An interesting illustration of the effect of excluding sunlight from a water derived from subterranean sources, and which had caused complaint, is given by Mr. G. H. Parker in a recent report, some of the details of which are as follows:

"The town of Brookline is supplied with water from a covered filter gallery. The water is pumped into two reservoirs, one of which is an iron tank supplying the high service. Complaint having been made that the water supplied from these reservoirs had an offensive taste and smell, while the water in the filter gallery, which was in darkness, remained free from any disagreeable qualities, it was deemed advisable to cover the high-service tank with a double roof, and ascertain whether the exclusion of light would prevent the development of the unpleasant changes.

"Examinations made subsequent to the covering of the tank showed that while the water in the filtering gallery continued to be clear, free from green algæ, and devoid of disagreeable taste or smell, and while the water from the open reservoir continued to show 'an abundant supply of green algæ, was slightly cloudy, and had a very strong taste and decidedly fishy smell,' the water from the high service tank, 'now completely darkened, contained only one specimen of green algæ, was now free from odor and taste, and for all practicable purposes as good as that pumped at the filter gallery.' It was concluded that the exclusion of light would be a complete remedy for the unpleasant effects, and the construction of a covered reservoir is contemplated."

Similar conclusions have been reached in England. Thomas Hawksley, the celebrated English engineer, testified in 1852 before the Select Committee on the Metropolis Water Supply Bill, that water taken from the new red sandstone was peculiarly liable to the growth of algæ if it was exposed to the sun, but that the exclusion of light and heat was a complete preventive. He also said that he had recommended covering a reservoir at Liverpool, a short time before, to avoid these unpleasant results.

The water of lakes and rivers may also be invaded by growths of algæ under favorable conditions. This growth is greatest in shallow open reservoirs, or ponds, where the water is comparatively still, and where it is exposed to a considerable elevation in temperature. In reservoirs exceeding 12 or 15 ft. in depth the growth does not appear to be so troublesome.

The danger of pollution from atmospheric impurities is greatest in the neighborhood of smoky cities. At London this was formerly the source of great annoyance. The surface of the water in reservoirs was often covered with a film of soot and dust, and if the water remained in the reservoir a sufficient time it acquired a bitter flavor.

The General Board of Health in its report in 1852 on the supply of water to the metropolis, in consideration of this trouble, and also of the fact that filtered water after exposure in open reservoirs frequently had to be strained before it could be used for domestic purposes, on account of growths of algæ in the reservoirs, arrived at the following conclusion: "Against the modern engineering practice of exposed and open reservoirs we would rather revert to the custom of the Roman engineers and recommend covering the service reservoirs and aqueducts to the utmost extent practicable."

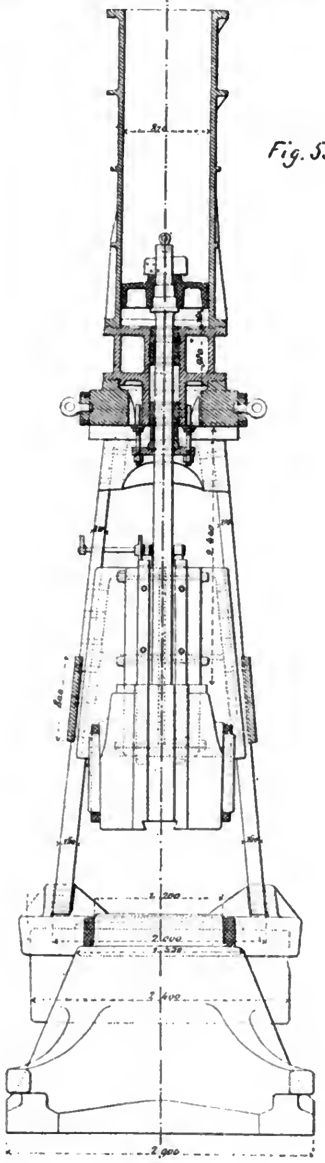
Influenced by similar considerations, the Select Committee of the House of Commons reported a bill, which

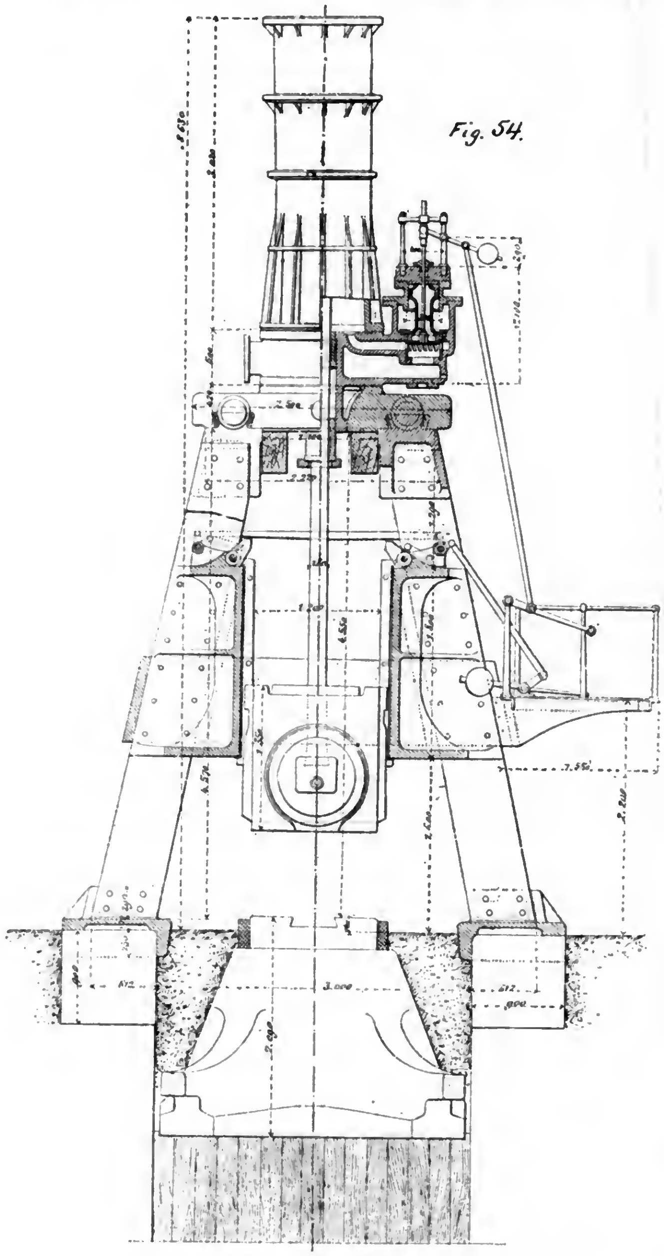
was passed July 1, 1852, containing the following clauses: "Every reservoir within a distance in a straight line from St. Paul's Cathedral in the City of London of not more than five miles, in which water for the supply for domestic use of the metropolis or any part thereof is stored or kept by any company, shall be roofed in or otherwise covered over: Provided always, that this provision shall not extend to any reservoir the water from which is subjected by the company to efficient filtration after it is discharged from such reservoir and before it is passed into the mains or pipes of the company for distribution, or to any reservoir the whole of the water from which is distributed through distinct mains or pipes for other than domestic purposes, nor to any reservoir whatever the water stored in which shall be used exclusively for other than domestic purposes. . . . No water shall be brought or conducted within the metropolis by any company for the purpose of domestic use, otherwise than through pipes or through covered aqueducts unless the same shall be afterward filtered before distribution."

English engineers, having in mind the conditions obtaining in England, appear to regard protection against soot and dust as the most important point, although they by no means ignore the importance of protection against heat and light.

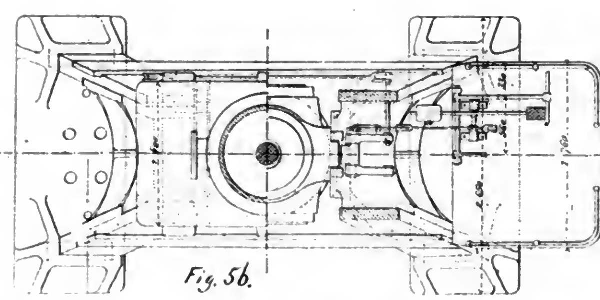
French engineers, on the other hand, seem to consider protection against solar influences as the most important. This naturally follows from the fact that French cities are much less smoky than English cities.

The atmospheric conditions in the United States resemble those of France, although there are localities in this





BIETRIX 15-TON HAMMER.



country which are as smoky as any in England. The need of covered reservoirs has been felt here for several years, especially since the use of ground-water as a supply and the practice of filtering have become common, and several have been constructed.

A covered reservoir does not usually present any serious difficulty to the engineer. It should be built of materials that are durable, and which are not liable to injure the quality of the water. Iron has been used for pillars, girders, or covering; but its use is to be avoided on account of its liability to corrosion. Small reservoirs may be covered with ordinary roofs or sheds; but these do not usually afford a sufficient protection against the heat. The best and most usual covering is of masonry or brickwork covered with a thin coating of asphalt to prevent the percolation of surface drainage, and by a layer of earth. The numerous covered reservoirs near London are mostly built in this way. It is usual to provide numerous ventilators.

The shape and constructive details are greatly dependent upon local conditions. The following types are common: 1. A circular reservoir covered with a flat dome. 2. A circular reservoir of larger size divided by circular walls into several annular compartments each of which is arched. 3. A rectangular reservoir divided longitudinally by straight walls into several compartments each of which is arched. 4. A reservoir covered by groined arches supported upon masonry piers. There are also variations of these types made by using iron. It is very common to make openings in the division walls thereby uniting two or more compartments. In some instances these openings are so extensive that the wall becomes virtually a series of piers.

[The paper gives a careful description of several covered reservoirs in France and Germany, which lack of space compels us to omit.]

The question as to the necessity of covering a reservoir must mainly depend upon local requirements and conditions. As a general guide it may be said that if the supply is from subterranean sources, or if it must be stored after being filtered, a covered reservoir is necessary, and that when a reservoir is amid smoky surroundings it should be covered. If the supply is from a river or lake, a covering is desirable, if the reservoir must needs be shallow. If the reservoir is deep, of large capacity, and not amid smoky surroundings, the necessity for covering diminishes and the question merges into one of cost. In the case of large storage reservoirs the expense of covering is generally prohibitory.

The best and most usual method of covering is by arches of masonry or brickwork, coated on the top with asphalt, and covered with two or three feet of earth, which may be turfed. Ventilation is important.

NOTES ON STEAM HAMMERS.

By C. Chomienne, Engineer.

(Translated from the French, under special arrangement with the Author, by Frederick Hobart.)

(*Continued from page 407.*)

CHAPTER XVIII.

THE BIETRIX 15-TON HAMMER.

This single-acting hammer was built in 1883 at the Bietrix Works, St. Etienne, France, for the Loirette Forge; it is shown in the accompanying illustrations, fig. 54 being an elevation, fig. 55 a side elevation, and fig. 56 a plan. The anvil-block is independent, and rests on oak-wood blocks placed below and strongly bolted together both below and above.

This hammer, especially intended for die-forging, is characterized by the use of wrought-iron legs or frames. These are four in number, having a section of 0.600 by 0.150 meter up to the slides, and of 0.550 by 0.110 meter up to the upper frame. They are joined at the lower end by a heavy shoe of cast iron resting upon a massive foundation of cut-stone masonry, and fixed to it by means of foundation bolts. On the wider faces of the frame and at one-half its height are two plates of wrought iron 0.800 by 0.080 meter, serving as cross-braces or ties. On the narrower faces are two blocks of cast iron bolted to the legs, upon which are fixed the slides made of forged steel. These frames are united together above on the inner side by cast-iron plates carrying dovetails upon which the upper frame is fixed. The space between the dovetails on these cast-iron blocks and those on the upper frame is filled by wooden keys, which secure a certain amount of elasticity and prevent breakage. At each end of the dovetails there is a lug which receives a bolt intended to unite the frame and the legs in a complete manner.

The platform, where the hammerman stands, is 2.200 meters above the ground. The distribution of steam is made by a circular valve, and the holding dogs are worked through levers by a foot-piece placed at the side of the hammerman.

The dimensions of this hammer are as follows:

Total weight of the striking parts...	15	tons.
Stroke	2.000	meters.
Diameter of the cylinder...........	0.820	meter.
Diameter of the piston-rod.........	0.300	meter.
Maximum travel of the piston-valve.	0.740	meter.
Weight of the anvil-block..........	65	tons.

The open space between the legs at the level of the ground being 3.000 meters, and the clear height under the slides being 1.600 meters, these hammers can be used both for forging and for drawing or stamping.

CHAPTER XIX.

THE CREUSOT 20-TON HAMMER.

This single-acting hammer, which is of very excellent design, is intended both for forging heavy pieces and for drawing down steel ingots; it is shown in the accompanying illustrations, fig. 57 being an elevation, fig. 58 a side elevation, fig. 59 a plan, and fig. 60 showing the cylinder and valves.

The lower frames are of cast iron, and though well separated, have great resistance to shocks; they are fixed upon the foundation block directly, and the exterior or outside foot forms a certain angle, avoiding in that way any lateral displacement. The legs are braced together at the height of the hammer by heavy wrought-iron plates, which are bolted through the frames.

The anvil-block rests upon a broad bed made of oak timbers, joined together by long bolts, and placed upon a foundation bed of beton. The anvil-block is made in two parts, of about the same width, and joined together by heavy bolts, which not only unite the two parts, but also secure the legs to the base. Each of the parts has a very wide base, and there are a number of holes in which can be placed levers to assist in moving it or placing it.

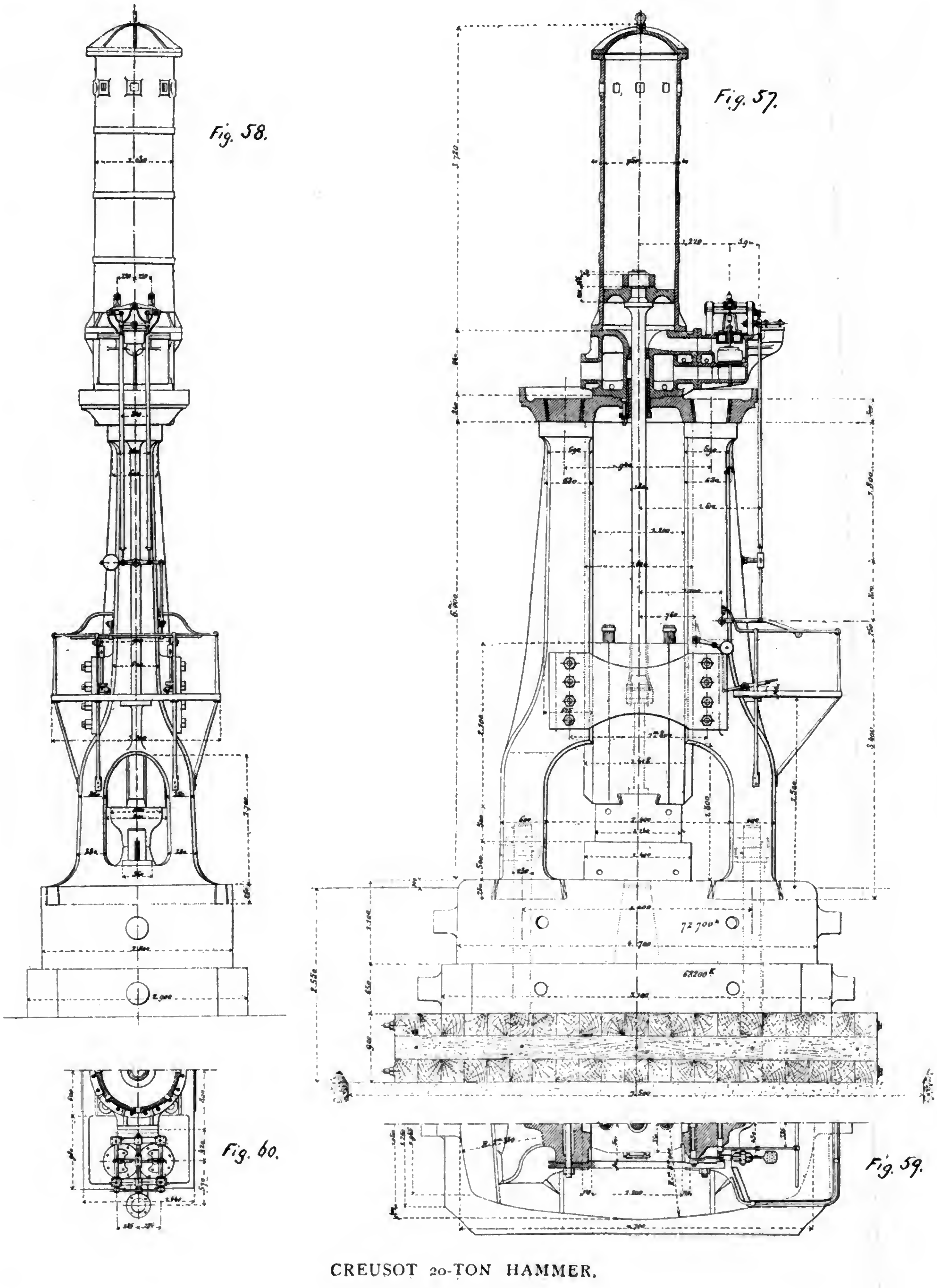
The stand for the hammerman is placed so high as to put him completely out of the way of the heat from the red-hot ingots and also the sparks, thus permitting him to work in entire security. We may remark upon this design that the lever moving the valves is very long, and that, moreover, there is a foot-lever connecting with the holding dog at each end of the platform, so that the hammerman may stand either on the right or the left-hand side, as the work requires, and can still be perfect master of the hammer.

The distribution of steam is made by means of balanced valves with double seats, as shown. These valves—usually placed in the same line, parallel to the axis of the hammer—are in this case placed upon the same line, but perpendicular to this axis. In this way the length of the steam-chest is very much reduced, and the size of the face on which it is joined to the cylinder is also very much reduced.

The piston is held to the rod by means of a cylindrical nut, over which an iron ring is sprung on hot.

The principal dimensions of this hammer are as follows:

Weight of striking part............	20	tons.
Maximum stroke....................	2.850	meters.
Diameter of cylinder	0.950	meter.
Diameter of steam-valve............	0.175	meter.



CREUSOT 20-TON HAMMER.

Fig. 61.

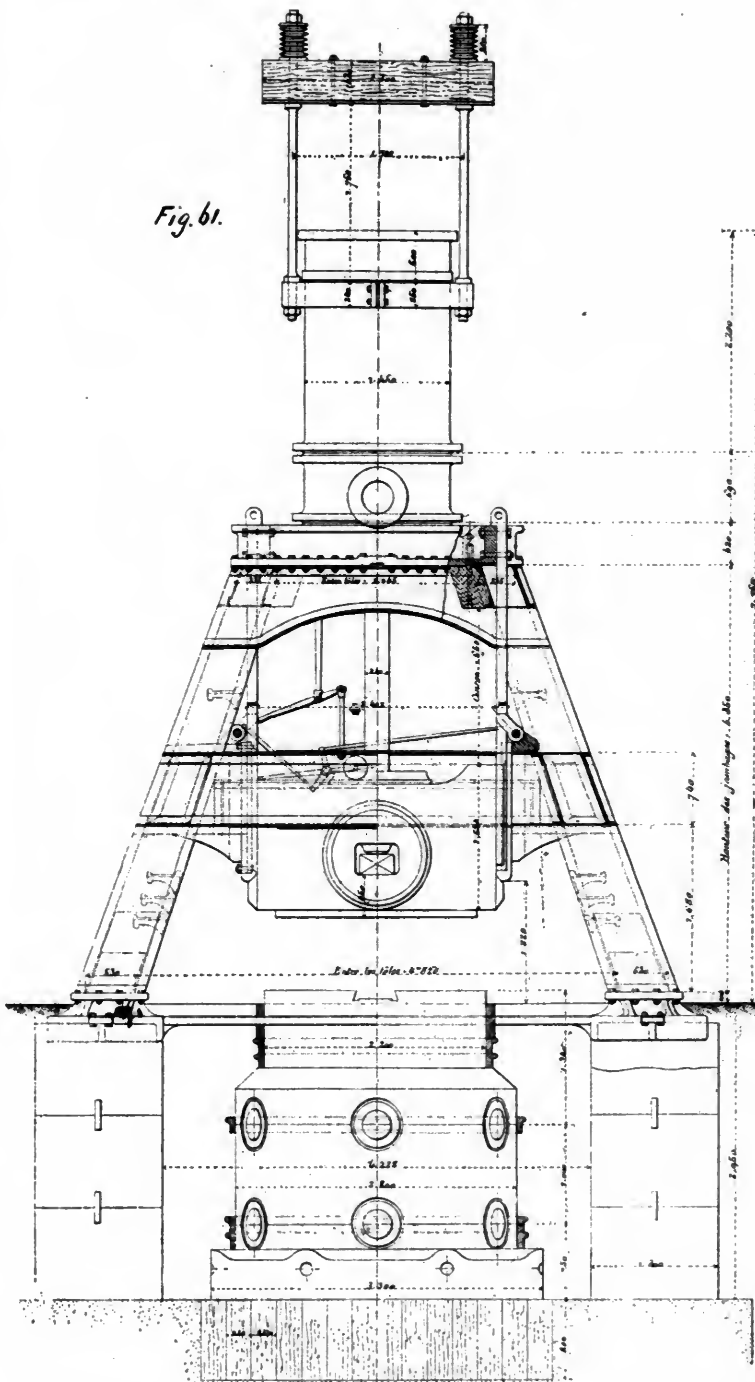
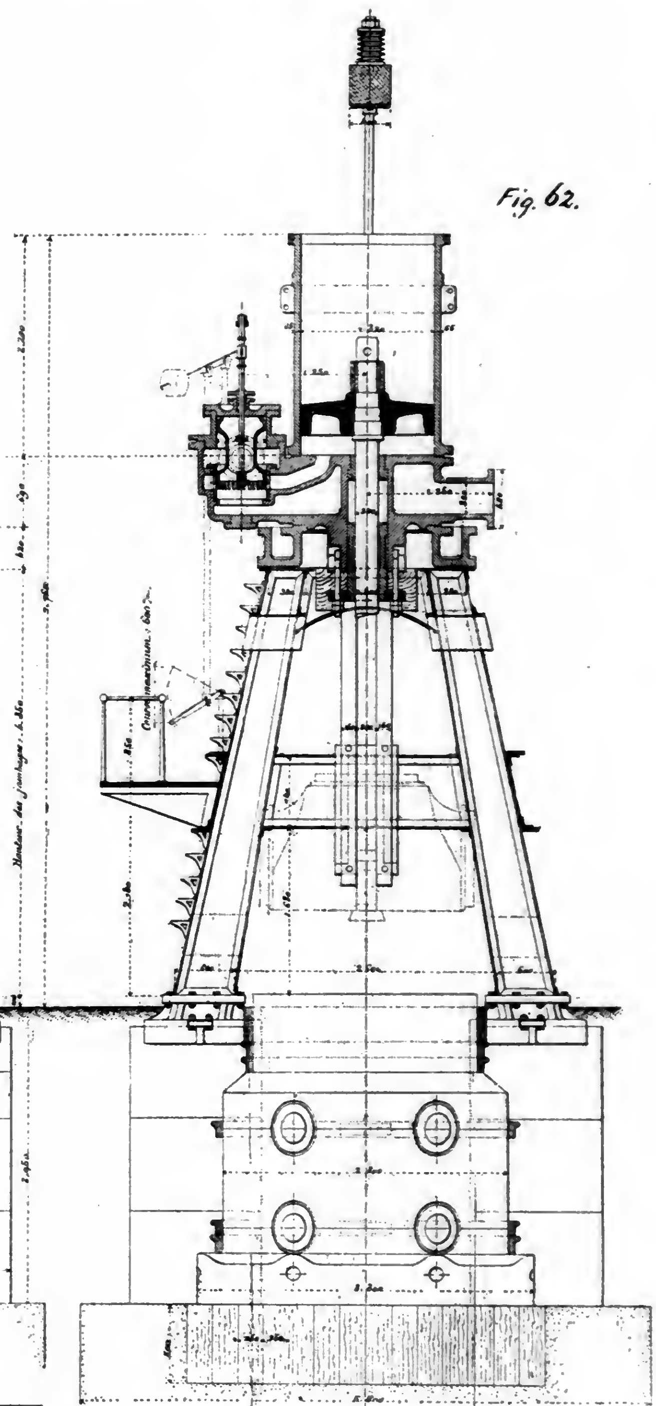


Fig. 62.



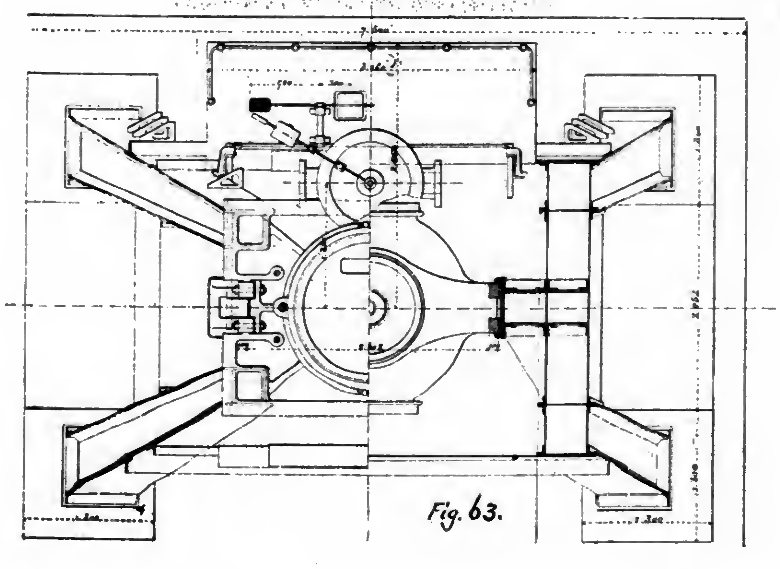


Fig. 63.

ARBEL 40-TON HAMMER.

Lift of steam-valve	0.023 meter.
Diameter of exhaust-valve	0.240 meter.
Lift of exhaust-valve	0.032 meter.
Total weight of anvil-block	141 tons.

This hammer, having a very long stroke, can be used to forge very heavy pieces, the anvil-block being well arranged both in respect to weight and base.

CHAPTER XX.

THE ARBEL 40-TON HAMMER.

This single-acting hammer was built in 1881 by the Compagnie de l'Horme, from a design of M. Lucien Arbel for his forges at Rive-de-Gier.

The anvil-block is independent, and is made in three parts, the upper part being 2.200 meters in diameter and weighing 45 tons, the middle piece 2.800 meters in diameter and weighing 46 tons, and the lower part forming a base 3.300 meters square and weighing 49 tons; the total weight of the base is thus 140 tons. All these three parts are solidly joined together by bolts and rings forming a compact whole; moreover, they have around them wrought-iron rings intended to prevent all breakage. The base rests upon a foundation of oak blocks set in a bed of masonry upon which are placed at the four corners of the anvil-block pillars of cut stone, supporting the independent shoes which carry the frame of the hammer. These pillars are joined together by heavy walls of masonry, and the space between the masonry and the anvil-block is filled in with sand carefully rammed down. The shoes are set into the top blocks of the masonry pillars and joined together by channel irons.

This hammer was especially intended for forging lcoomotive wheels up to 2.300 meters in diameter, and other very wide forgings, and is characterized by the use of a frame consisting of four pillars made of wrought-iron plates and angles. These pillars are joined together at the lower end of the slides by wrought-iron plates forming cross-braces and securing absolute rigidity. The lower cross-braces also serve as points of attachment for the slides, which are made of forged steel and which are secured above to the upper frame; they carry upon this part a shoulder, which, under the action of the heavy shock produced by the hammer striking against the holding dogs, prevents any cutting of the bolts.

The legs are bolted below to the cast-iron shoes of the foundation and above to the upper frame.

The lower cross-brace, which is placed upon the wide face of the frame, serves to carry the platform for the hammerman. In this position he is completely out of the way of the heat from the forging, but nevertheless sees all that is going on below, and can avoid all danger.

The distribution of steam is made by a circular balance-valve moved by hand-levers. The two holding dogs are worked by a lever placed at one side of the hammerman.

The principal dimensions of this hammer are as follows:

Total weight of striking mass	40 tons.
Maximum stroke	1.650 meters.
Diameter of the cylinder	1.320 meters.
Diameter of the piston-valve	0.510 meter.
Maximum stroke of valve	0.170 meter.
Weight of the anvil-block	140 tons.

The distance apart of the frames at the level of the ground being 4.820 meters one way and 2.600 meters on the other, it follows that the dies for the forgings are perfectly free, and that all the maneuvers required in forging the wheels can be made with great ease, and the changes of the dies can also be very readily made.

It will be seen that all the French and Belgian hammers described are single-acting—that is, use steam only to lift the hammer, depending upon the weight of the working parts entirely for the blow—this type being the one in almost universal use in those countries. In England, as will be seen further on, much use is made of the double-acting hammer, in which steam is used on both sides of the piston, aiding in the blow as well as lifting the hammer.

(TO BE CONTINUED.)

ENGINES OF THE STEAMER "CONNECTICUT."

THE steamer *Connecticut*, an engraving of which was given in the August number of the RAILROAD AND ENGINEERING JOURNAL, is provided with an engine of a type not unusual abroad, but almost new here, and differing widely from the beam engine which has been almost universally employed in our Eastern waters. This engine, which is shown in the accompanying illustration, was, like the boat itself, designed by Mr. George B. Mallory; it has been built under his supervision by the William Cramp & Sons Ship & Engine Building Company, of Philadelphia. It is a compound oscillating engine—the largest of the kind ever built in this country—having a high-pressure cylinder 56½ in. diameter, and a low-pressure cylinder 104 in. diameter, both having 11-ft. stroke.

The steam-port nozzles for the high-pressure cylinder are 6 × 41 in. inside, and those for the low-pressure cylinder, 8½ × 100 in. inside. The steam passes through the high-pressure trunnion through a composition stuffing-box sleeve 24 in. inside diameter, surrounded by stuffing-boxes and double air-spaces. From the trunnion it passes through a side-pipe 18 in. inside diameter to the valve-chest. From the exhaust chests the steam passes to the exhaust trunnion through a 22-in. side-pipe. The high-pressure exhaust trunnion is connected with the low-pressure trunnion by a receiver-pipe 26 in. inside diameter, having an easy bend and surrounded by a steam-jacket with 2-in. spaces. The exhaust side-pipe on the low-pressure cylinder is 33 in. diameter; from the exhaust trunnion the steam passes through a grease-extractor, and thence to the steam space in the surface-condenser through a copper-pipe 33 in. diameter.

The cylinders are cast without heads, the heads and steam-chests being bolted on; the upper head of each cylinder is fitted with heavy double brackets for guides for each piston-rod, those for the small cylinder being 15 in., and those for the large cylinder 21 in. long.

The pistons have cast-iron rings, and steel springs are provided for setting out these rings. The piston rods for the high-pressure cylinder are 9 in., and those for the low-pressure cylinder 10 in. diameter.

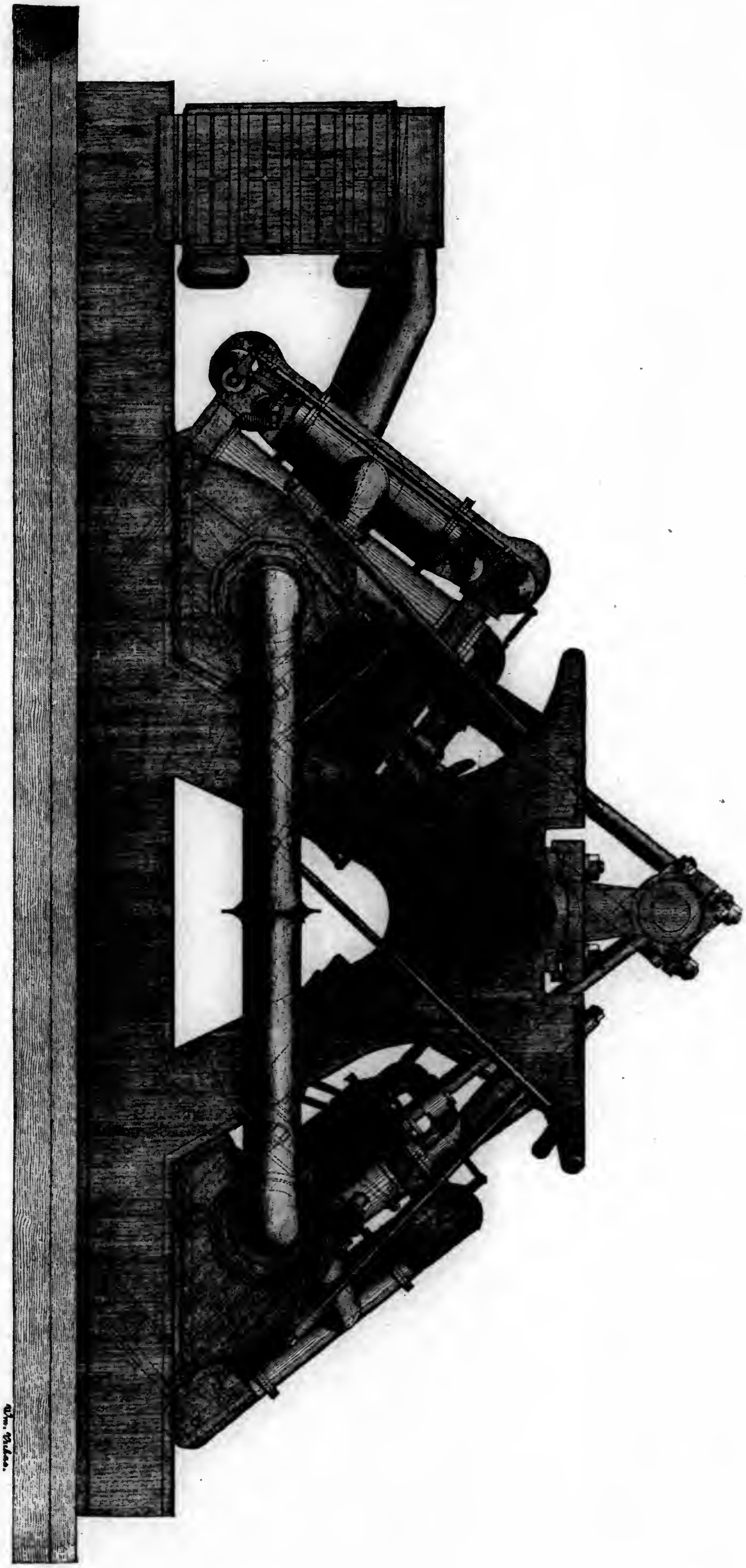
The valve-gear is Wheelock's improved gridiron, with automatic trip cut-off. The steam opening on the high-pressure cylinder is 6½ × 52 in., and the exhaust opening 11½ × 52 in., while on the low-pressure cylinder the openings are 9⅞ × 102 in. and 19½ × 102 in., respectively. The valve motion is of the link type, and there are three eccentrics, two for the link and one for the cut-off. A small steam-engine is provided for working the reverse-lever and adjusting the valve-gear.

The surface-condenser is of cast iron, box form, containing 3,916 brass tubes ⅝ in. outside diameter, the distance between the tube-sheets being 16 ft. The exposed surface is about 12,150 square feet. An auxiliary condenser is also provided, having about 750 square feet of exposed tube surface.

There are two single-acting air-pumps 35 in. diameter and 17-in. stroke; four feed-pumps 5 in. diameter and 17-in. stroke, and two bilge-pumps of the same size. These eight pumps are arranged in two sets of four each, worked from a horizontal crank-shaft, and between the two sets is placed the engine which works them, a compound engine with high-pressure cylinder 14 in., low-pressure 24 in. diameter, both 17-in. stroke. There is also an auxiliary air and circulating pump. The main circulating pump is a centrifugal pump with suction and delivery pipe each 16 in. in diameter.

The engine is carried by two heavy keelsons of steel plates and angle-irons, upon which are the A-shaped gallows frames of box girders built up of wrought-iron plates and angles. These frames are connected by sway-braces, and carry on top the pillow-blocks for the main shaft. The keelsons rest on yellow pine keelsons on top of the cross-floors, and are securely bolted to and through the hull timbers. The condenser is carried on the after end of the steel keelsons.

The crank is of the built-up form, the crank-pin having a bearing 18 in. diameter and 49 in. long. It is shrunk



COMPOUND OSCILLATING ENGINE FOR STEAMER "CONNECTICUT."

DESIGNED BY GEORGE B. MALLORY FOR THE PROVIDENCE & STONINGTON STEAMSHIP COMPANY.

into one crank-arm, and secured by a nut at one end and gibs at the other. The crank-arms are also shrunk on and keyed to the ends of the two shafts, each of which is 33 ft. 6 in. long, and has journals 23 and 25 in. diameter.

The boat has feathering paddle-wheels 28 ft. diameter between centers of the bucket trunnions. There are 12 buckets, each 14 ft. face and 4 ft. 6 in. wide. The buckets are of oak 4½ in. thick. The wheel-frame carries bearings for the bucket trunnions, and the feathering motion is given by eccentrics keyed on the main shaft.

Steam is furnished by six boilers of the "gunboat" type, each 12 ft. 6 in. diameter and 20 ft. 1¾ in. extreme length. These boilers carry 120 lbs. working pressure, and are of steel, all rivet-holes drilled, the outside shell ¾ in. thick. In each boiler there are three corrugated furnaces 48 in. inside diameter and 7 ft. 6 in. long; back of the furnaces is a deep combustion chamber from which run 424 tubes 3¼ in. diameter and 8 ft. long. The boilers are arranged in two sets of three each, and over each set is a superheater 11 ft. diameter and 12 ft. extreme height, having a single flue 7 ft. 6 in. diameter. The smoke-stacks stand directly on the superheaters.

There is also a donkey-boiler of the locomotive type 7 ft. diameter of barrel and 12 ft. long over all, made of steel. It has 156 tubes 3 in. diameter. Six independent steam-pumps are provided for feed and other purposes.

This engine is expected to develop about 4,500 indicated H.P. at 25 revolutions per minute, with a full load—about 500 tons—on board. When driven at full power, 5,500 H.P. will be developed, and a speed of 19½ miles per hour obtained for the vessel.

This engine is, as will be seen from the engraving, of a very neat and compact design. It has the great advantages of economizing space and of placing all the weight low down in the vessel, while the number of parts is necessarily less than in the beam type.

A RAILROAD SCHOOL IN EUROPE.

(Note of M. Bela Ambrozovics, in the *Bulletin* of the Commission of the International Railroad Congress.)

It might be said that every railroad charter constitutes a monopoly. The reason is that functions of the railroads are extremely important, so that the public safety is concerned in their management, and their powers may be confounded with those of the State in all countries more or less subject to the encroachment of public authorities. In fact, if we inquire how railroads in their capacity of commercial enterprises differ essentially from former methods of transportation, we find that it is in this idea of monopoly. The protection against competition which is conferred upon them, the right to condemn real estate, and other privileges which have been conceded in many states are so many methods of preserving this monopoly, which would, perhaps, exist even without them, owing to the immense amount of capital required and to the understood, although not expressed, union which existed between these companies to protect their interests. This is also the case even in these countries where the State does not own any interest in railroads and where it has not aided them by subsidies or by guarantees of revenue.

Now in our view the monopoly of providing for indispensable public needs—and certainly the services of the railroads become indispensable only too soon after they are established—is properly the right of the State alone. The exercise of this right may, perhaps, be transferred to private persons or associations, but the State, as original owner of the right, cannot evade the obligation to exercise the influence necessary to secure or preserve the great interests which are concerned, and of which is the natural protector.

For instance, in everything concerning the interests of the public—both travelers and other persons—the great speed at which railroad trains now travel is a constant and unavoidable source of danger to life and limb, and requires costly and elaborate measures of precaution. It is only prudent foresight not to leave the decision of questions as to these precautions to the partial and prejudiced judgment of those who are directly interested in the expenses of construction and management of the railroad; and it is the State alone which should be authorized to prescribe these measures of precaution, holding as supreme arbiter the just medium between the interests of the public and the companies—it is the State which must be both judge and executioner whenever accidents result from criminal negligence.

The degree and method of the interference of public authority in support of the rights and obligations of the State, relative to these two principal points of view, to which are joined a number of others, depending upon how far the functions of the railroad company touch the rights, just or pretended, of the public administration, vary widely in different countries, according to the prevailing views of government, the manners, the customs, the social and administrative institutions, and many other circumstances. And it might be said that, in general, the intervention of the State is now everywhere increasing rather than diminishing in greater or less measure as the power of the railroad companies, which increases inevitably from day to day, makes itself felt by interests before untouched, and has in consequence new advocates continually appearing in favor of proper restraint upon this power.

This tendency is very marked with us in Hungary, where we find these distinctive traits of railroad companies of which we have spoken, and the result is that the functions of the railroads are considered as public services, and as such an essential part of the administration of the State; this view, however, although perhaps somewhat more marked with us, does not differ from that held in most countries in Europe.

The preliminary survey, the location, the construction, and the management of the railroads with us are regulated through special concessions granted in accordance with law, or under the provisions of a general law.

All the relations of railroads as corporations to the State, to the public, to the stockholders, and to their employés, all the fundamental rules to be observed in the construction and management, are established and regulated either by law or by rules made or approved by the Government. Even outside of this all general and detailed rules of instruction, relative to the railroad service, must be submitted to the approval of the Government. Even the employment of agents or workmen is subject to rules laid down by the Government.

Under all these conditions a strict watch and control is exercised by the agents of the Government. Thus a Government commissioner is present at all the meetings of the railroad managements, or, if this should be omitted, the minutes of the meetings must be submitted to the proper bureau; a consulting engineer is appointed to watch the construction of railroads, while the Government inspectors examine their management; these last-named officers, whose authority extends over both the railroads owned by the State and those owned by companies, possess disciplinary power over the executive officers of the roads.

All employés or agents of railroads without exception are obliged to take an official oath, in virtue of which, however, they are invested with certain limited police powers on their respective lines.

It follows naturally that when this position is once taken the State cannot stop. We have erected a wall to guard against encroachment, but we find continually breaches in this direction, and we find also that as the railroads advance on their side and in their way the Government must advance on parallel lines.

In our case a special reason is found to search for these breaches in the peculiar situation of Hungary, both from a political and economical point of view, from which it has resulted that with us the idea of State intervention has been much further developed than in other countries.

But what we have especially to speak of here is to describe what it has recently been deemed proper to do in relation to the instruction of employés for service in the railroad management and especially at stations. Heretofore instruction of this kind has been given by the railroad managers themselves, and chiefly in a practical way and in actual service. The Government has, it is true, pre-

scribed certain general rules for the degree of knowledge which persons must have before entering on this service. For over 12 years past we have adopted the principle that those railroad officers who come in contact with the public and who have to make reports should be better instructed than those who are only required to go through a certain amount of strictly routine work.

This superior knowledge involves a certain degree of education, which is usually accompanied by a corresponding elevation of sentiment. Thus for these positions it was required that the candidates must have passed through certain classes of a public high school (*gymnasium*), or of a technical school of the second class, or through a commercial or military school of the same standing, and where they had not taken such a course they were subjected to an examination.

These regulations, as we have said, have been in existence for a number of years, and there was no school or course of theoretical instruction adapted to the special needs of the candidate for railroad service. There has been in the Commercial Academy at Buda-Pesth for several years a course aided by the Government; but under the existing system this has not been successful, chiefly because there was no certainty that the students would be admitted to railroad service after they completed their course. They were sent immediately after graduating, without taking any special studies, to different stations, and it was only by their own ability, aided by such help as they might receive from the chief of the station, that they learned the indispensable knowledge and also the practical skill required for the service. After having passed the prescribed examination before an agent of the General Inspection, and after having been in service at least three months, these students could then be appointed permanent employés, but there was no obligation on the part of the companies to give them positions.

Such are the principal features of the system heretofore followed in this matter of appointing employés for the service of railroads—that is, to all positions where the technical knowledge of an engineer was not required. This system, however, was found to be full of imperfections, and did not serve well the interests either of the railroad service or of the State.

Thanks to the energy of the present Minister of Public Works and Communications, M. Gabriel de Baross, it has been replaced by another, based upon a scientific and uniform course of instruction and made obligatory at once on the students and the companies.

Under this system there has been established at Buda-Pesth, with the concurrence of the railroad companies, a course of instruction for employés in the management and the commercial service of the lines. The organization of this course was prescribed in a system of rules, dated December 21, 1886, the formal document being signed by the representatives of all the chief railroad companies—ten in number—and approved by the Minister.

We give below the full text of these regulations, with the exception of the first article, which is merely a formal repetition of what we have said in the preceding paragraph:

RULES FOR THE RAILROAD SCHOOL.

Article 2.—The course of instruction is under the immediate supervision of a commission, the head of which is a Secretary of the Ministry of Public Works, and which is composed of the Chief of the Department of Railroads, the Chief of the interested section of the said ministry, a delegate appointed by the Minister of Public Instruction, a delegate from the General Bureau of Inspection of Railroads, and a delegate from the management of each one of the railroad companies interested. This Commission will establish rules under which it will exercise its direction; which rules must be approved by the Minister of Public Works.

Article 3.—The agents of this Commission are the Chief Administrator, the Secretary, and the professors who may be appointed, and who will all be subordinate officers of the Commission. As professors, no person can be employed who is not actively in the service of a Hungarian railroad, with the exception of teachers of the points 5, 6, 7 and 9 named in Article 7.

Article 4.—The Chief Administrator—who in all cases must be chosen from among the professors—as well as the professors and other instructors, shall be appointed by the Minister of Public Work, on the nomination of the Commission. The Secretary shall be appointed by the same Minister from among the officers now employed in his bureau. It must be understood that the Chief Administrator and the professors in accepting their appointment contract to remain in service for at least three years; they can, however, be changed or removed by the Minister of Public Works on request of the Commission.

Article 5.—The rights and the duties of the Administrator and the Secretary, as well as those of the professors, and the relations of the latter to the Administrator, shall be established by special rules to be made by the Commission.

Article 6.—The language of the course is to be Hungarian; and no other is to be used.

Article 7.—The studies to be included in the course are:

1. Railroad technology.
2. Telegraph service.
3. The service of management, properly so called.
4. The commercial or traffic service.
5. Railroad geography.
6. Railroad history.
7. Laws and legislation concerning railroads.
8. Commercial arithmetic and railroad accounts.
9. Knowledge of different class of merchandise.

In addition to these there may be added as optional studies:

1. The German language.
2. The French language.

The degree and extent of the instruction in these different branches shall be established in a programme or course prepared by the Commission after consultation with the professors, and approved by the Ministry.

Article 8.—There shall be three classes of students:

1. The regular public students, including the students recommended by the railroad companies, and also voluntary students who attend the lessons regularly throughout the year. If the number of the first class exceed that fixed by the Commission, their admission may be limited, the number sent by each company to be in proportion to its contribution for the expenses of the course.

2. The private students are those who are already either permanently or temporarily in the active service of the railroads, and who at the beginning of the course or during the year are designated by their managements for admission to the final examination of the course.

3. Special public students are those who, being actively in the service of the railroads, only desire to study certain subjects in order to increase their knowledge, but without being under any obligations to attend the final examination; at the close of the course they receive a simple certificate of attendance.

As regular public students, or as private students only, such persons can be admitted as have taken the regular school course prescribed heretofore, and have attained the age of 18 years. They must in addition have their physical health and strength certified to by the Chief Surgeon of one of the railroads. They must submit to an examination for admission, the conditions of which will be established by the Supervisory Commission. It is provided, however, that this examination will not be required from those students who have passed successfully the final examination of a high school (*gymnasium*), or of a second-class technical school, or a commercial academy. There will also be admitted without examination persons who have served in the army or the territorial militia and have passed examination for an officer's commission, provided they possess a knowledge of the Hungarian language.

Article 9.—The course will commence on September 1 of each year, and will last ten months. At the end of this time the students who have attended lessons diligently and with success, and have the proper certificates, are assigned by the Commission to the different railroads, to acquire practical knowledge and to serve on trial and at their own expense. This trial service is to last three months continuously, and when it is completed successfully the students are admitted to the final examination.

Those regular public students, however, who have been admitted on recommendation of the railroad companies, and who have a certificate that they have already been in active service at least three months before beginning the course, may be admitted at once to the final examination. The private students, on the other hand, can only be admitted to the final examination after having been in active service at least 13 months.

The examinations are made by special commissions, which include a President named by the Minister, an officer of the general inspection, two members of the Supervisory Commission, and the professor. When an employé of one of the railroads is examined, it is always necessary that the representative of that railroad on the Supervisory Commission shall be one of the examining committee. In addition, each railroad company is entitled when its employés are examined to send two delegates to represent it. These delegates will not only have a right to ask questions of the candidate, but they will have also a vote in deciding the result, and the candidate will not be considered to have passed unless two of the three representatives of his company concur.

Other members of the Supervisory Commission have also the right to be present at the examinations and ask questions; but they will not have the right to vote on the final decision.

Regular public students and private students who fail to pass the final examination on one or more subjects can, by the permission of the Minister, be admitted to a second examination; but if they fail on this no further examination will be allowed.

The regulations for the examinations will be made by the Supervisory Commission, with the approval of the Minister.

Article 10.—Certificates of success will be recognized by all the railroad companies in the following manner:

1. Persons furnished with these certificates will not be obliged to undergo the examinations for telegraph service or commercial service which have been heretofore required.

2. After October 1, 1889, no person can be appointed to positions in these branches of the service who have not one of these certificates of examination.

The railroad companies, nevertheless, have reserved the right to judge of the practical knowledge of those who have received certificates by appointing them temporarily for three months; at the end of that time the company may require them to pass a special examination in the rules and instructions especially required by local circumstances on that particular line. These supplementary examinations will be under the control of the Supervisory Commission, and due notice of time and place shall be given. From October 1, 1888, the special examinations for telegraph and commercial service, heretofore in use, will be discontinued.

Article 11.—The library of the Ministry of Public Works will be open to professors and students in this course, and in addition a library of technical books and a museum will be established, especially for the use of the course. The Minister will cause to be transferred to the museum all the means of instruction—instruments, apparatus, models, books, drawings, etc.—which were provided for the use of the experimental course and remain in the charge of the Commercial Academy at Buda-Pesth. The Minister and the railroad companies further agree to provide such instruments, models, plans, etc., as may be found necessary for the museum, and to transfer them to it. The Supervisory Commission will also make arrangements with the railroads having stations and workshops at Buda-Pesth, under which the students will be able to acquire practical knowledge and receive practical lessons under the directions of the professors.

Article 12.—The regular public students and the extraordinary students will be required to pay a fee of 70 florins ($26) yearly. All these fees will be applied for the benefit of the school. The examination fee is fixed at 10 florins ($3.70) for each person; the latter amounts to be applied to pay the expenses of the Examining Committee.

Article 13.—All the expenses of the course, including the salaries of the Director, the Secretary, and the professors; heating, lighting, and care of buildings, etc.—in general, all personal and material expenses—shall be paid in equal shares by the Ministry of Public Works and the railroad companies, including the State Railroads. The half which is payable by the railroads will be divided among them in proportion to the mileage on their lines. The annual amount required will be fixed by the Supervisory Commission, subject to the approval of the Minister; the railroads are required to pay their proportion quarterly. At the end of the year a full statement of accounts, including statements of all receipts and expenses, will be prepared and published. Should any surplus remain, it will be returned to the contributors.

All the regulations which have been given are now in full operation, the rules of the Commission having been established, the professors appointed, and the actual course of instruction having begun, September 3, 1887. The most interesting point in the detailed rules is that each of the professors is required to write during his first year's service a book of instruction on the subject which is assigned to him.

Thus it is that the plan for which a simple wish was expressed in the Congress at Milan has already become an actual fact in Hungary—a consummation for which we hardly dared dream three years ago.

Thus we see in the Hungarian system a happy combination of theory and practice, which appears to provide for all exigencies which may arise, and which has also been so prepared as to conciliate all the interests concerned to make friends of both sides and to disarm those who were at first opposed to it. We see also the strong hand of the State placed upon one of the most important questions which has been presented in railroad management.

It appears to us that this system has a claim for serious consideration and that it merits careful and thorough trial in other countries, with such modifications as may be indicated by the special circumstances of each nation.

Electric Light Plant on the Steamer "Connecticut."

THE new steamer *Connecticut* of the Providence & Stonington Steamship Company's line is lighted throughout with electric lights, the entire plant having been furnished by the United States Electric Lighting Company of New York, under the supervision of Mr. George B. Mallory, the engineer who designed the vessel. The object kept in view in this case was to make the plant a representative one of this kind, and, if possible, better than anything which had before been put on a passenger boat, and the utmost care was used in all the arrangements.

The dynamos used are of the pattern adopted by the United States Company, and are shown in the accompanying illustration, fig. 1 being a front view, and fig. 2 an end view. These dynamos are run by engines of the Brotherhood three-cylinder type, each capable of delivering 45 H.P., and arranged to run at a speed of about 950 revolutions per minute. This high speed permits the coupling of the engine direct to the dynamo shaft, without the use of gearing or pulleys, thus making an extremely compact design. The connection is made by means of an ingenious flexible coupling, especially designed for this purpose, and great stiffness and stability is obtained by

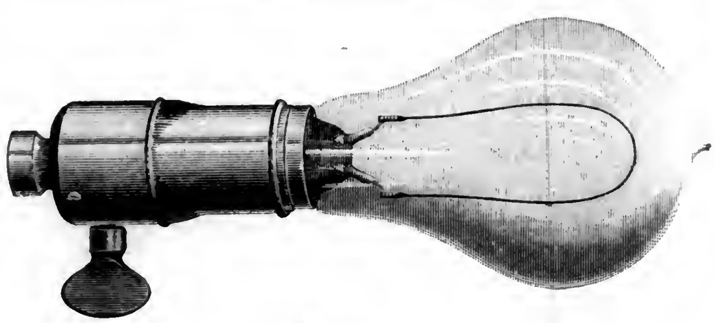


Fig. 3.

having both engine and dynamo fastened to the same bed-plate. This arrangement further secures economy of space and weight, and very little noise in running.

In order to avoid any possible annoyance to the passengers, the machinery is located in the hold forward, and in putting it in place every precaution has been taken to provide against vibration, and against the humming which is so often complained of with electric light plants. The foundations are composed of two layers of 4-in. yellow pine planks securely fastened to the keelson; a layer arranged that at any time in the night, by merely turning a switch, he can tell whether the plant is being properly cared for.

The 800 lights are distributed over every portion of the boat, not only in the cabins but in the engine-rooms, on deck, etc., and, in fact, the whole boat is supplied with these lights. The greatest care has been given to every detail of the wiring system in order to provide against and overcome the many difficulties attendant on maintaining the insulations of an electric light system on ship-

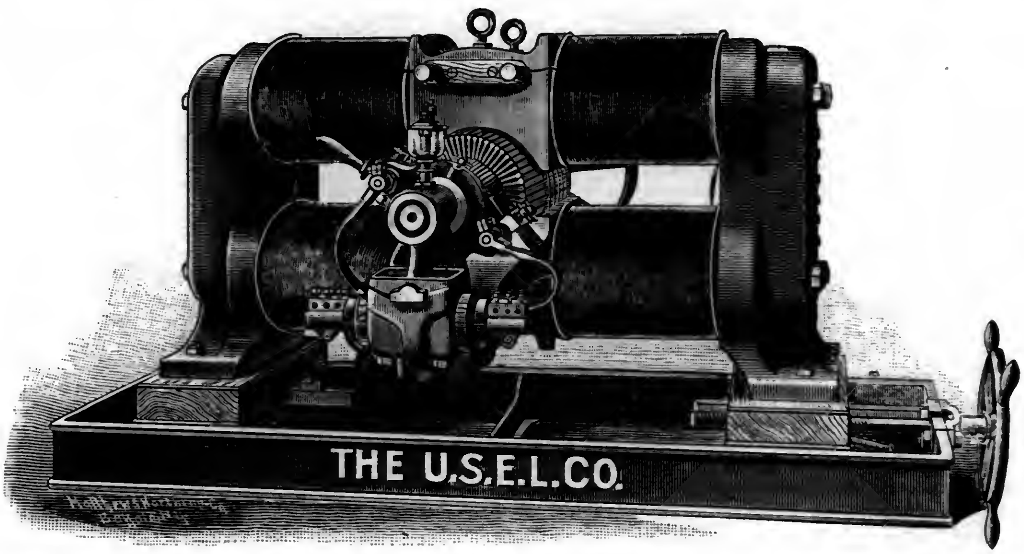


Fig. 1.

of felt is placed between the two layers of plank and another one between the upper layer of plank and the iron bed-plate of the machinery.

The boot is wired for 800 lights of 16 candle-power, which are distributed on a dozen different circuits. The lights are of the incandescent type usually employed by this company, and one of them is shown in fig. 3. The main wire of each of the circuits starts from the main board at a high point; also to provide against any unforeseen difficulty which may arise. A very high insulation wire has been used throughout, and all the wires used below deck have been encased in lead, then covered by wooden moldings. The wiring is entirely concealed, none of it being visible in any part of the boat outside of the engine-room.

The safety devices, lamp-sockets, switches, etc , have

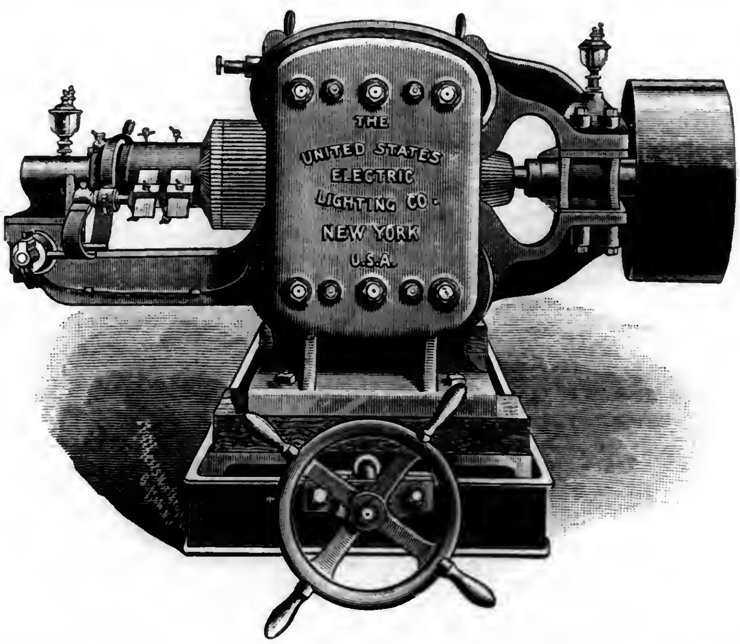


Fig. 2.

switch-board of the dynamo room, and at this switch-board the two dynamos, each of 400 light capacity, are coupled in parallel, each dynamo main having an ampère-meter in circuit to show the load. On the same board there is also placed a Cardew volt-meter and the rheostats. There are also in the engine-room duplicates of all these instruments, so that the engineer can at all times tell whether the man who is running the dynamos is properly attending to his duties; as a further precaution an indicator is placed in the state-room of the Chief Engineer, so all been carefully designed for this special plant, and in designing them pains has been taken to prevent the exposure of anything which may interfere with or disfigure the decorations of the boat. Care has also been taken to so arrange the system that it will require as little attention as possible while in operation, and the power required from the engines is governed by the number of lights in use.

The plant is now practically completed, and will shortly be subjected to thorough and careful tests.

CATECHISM OF THE LOCOMOTIVE.

(Revised and enlarged.)

By M. N. Forney.

(Continued from page 425.)

CHAPTER XVI.

THE RUNNING GEAR.

QUESTION 422. *What is meant by the running gear of a locomotive?*

Answer. It means those parts, such as the wheels, axles, and frames, which carry the other parts of the engine. As the Germans express it, it is the "*wagon*" of the locomotive.

QUESTION 423. *How may the wheels be classified?*

Answer. As *driving* and *carrying* or *truck wheels.*

QUESTION 424. *What service must the driving-wheels perform?*

Answer. The driving-wheels, as indicated by their name, "drive" or move the locomotive on the track, as was explained in answer to Questions 274, 275, and 276. As their adhesion depends upon the pressure with which they bear upon the rails, they must carry either a part or the whole of the weight of the engine.

QUESTION 425. *What is a "truck" of a locomotive?*

Answer. A *truck* consists of one or more pairs of wheels which are held in a separate frame, which is connected to the locomotive by a flexible connection—usually a *king-bolt* or *center-pin*—somewhat as the front axle of an ordinary wagon or carriage is fastened to the body. The truck is not connected rigidly to the rest of the locomotive, but it can turn or oscillate about the king-bolt, so that the axles can assume positions which approximate to that of radii of the curves of the track. In Plates III, IV, and V, 6 6 are the truck wheels, 7 5 the truck frame, and 9 8, Plate IV, the center-pin, around which the truck frame turns.

QUESTION 426. *What service does the truck perform?*

Answer. It usually carries the weight of the front end of the locomotive, and also guides it into and around curves and *switches.** Sometimes a truck is placed under the back end of a locomotive to carry part of its weight.

QUESTION 427. *How does a truck guide a locomotive on a curved track?*

Answer. It does it very much in the same way as the front wheels of an ordinary wagon enable it to turn around corners—that is, the truck wheels being attached to a separate frame, which is connected to the locomotive by a center-pin, can turn just as the front axle of an ordinary wagon can which is connected to the body by a kingbolt.

QUESTION 428. *Why are two pairs of wheels usually used on a locomotive truck instead of one, as on an ordinary wagon?*

Answer. Because it is necessary to have one pair of wheels guide the other. In a wagon the front axle is guided by the pole or shafts. Nearly every one knows the difficulty of moving such a vehicle when the pole or shafts are removed, especially if it be pushed from behind. The movement of the front axle is then uncontrolled, and it is impossible to direct its movement. The same thing would occur with a locomotive if a single pair of wheels were used and attached in the same way as the front axle of a wagon. Thus if a single pair of wheels was connected to a locomotive by a center-pin, *s*, fig. 263, so that the axle would be free to move around this pin, then if one of the wheels should strike an obstruction, say a stone, *a*, fig. 265, there would be nothing to prevent the axle from being thrown into the position shown in fig. 264, and the wheels would be liable to leave the track. When two pairs of wheels are used, as shown in fig. 266, and both axles attached to the same frame, which is connected to the engine by a center-pin, *s*, between the two axles, then the wheels in moving round the center-pin must move around it in arcs of circles, *m n*, *m n*, described from the center *s*. These arcs, it will be observed, cross the rails. Now, if the wheels should move in the direction indicated by the arcs, the flange of one of them would come in contact with the rail and prevent it from moving any farther. It is, therefore, evident that wheels arranged in that way can only move about the center-pin as far as the curvature of the track will permit. Trucks are sometimes used with only one pair of wheels, but the center-pin is then placed some distance behind the center of the axle, or in the same relation to it that the center *s* is to the axle *a a'*, in fig. 266. It is evident, then, that if the frame for such a truck turns around the center-pin, the wheels must move across the track in the same way as represented by the arcs *m n*, in fig. 266. The construction and operation of trucks with a single pair of wheels will be more fully explained hereafter.

* A switch is a movable pair of rails, by which a locomotive is enabled to run from one track to another.

QUESTION 429. *Why will a locomotive run around curves easier if the front axles are attached to a truck frame which is connected to the locomotive by a flexible connection?*

Answer. Because the truck axles can then assume positions which conform very nearly to the radii of the curves of the track, and it is well known that if two or more axles, each with a pair of wheels on it, are attached to a frame with their center lines parallel with each other, as shown in fig. 267, they will roll in a straight line, but if the center lines of the axles are inclined to each other, as shown in fig. 268, the tendency will be to roll in a curve, the radius of which will depend upon the degree of inclination of the axles to each other. In order to make the wheels in fig. 267 roll on the curves *c d* and *a b*, it will be necessary to slide them laterally a distance equal to that between the curves and the straight lines *q r* and *o n*, and as the length of the outside curve is greater than the inside one, if the wheels are fastened to the axles so they cannot turn on them and roll on the curves, either the wheels on the inside or those on the outside must slip a distance equal to the difference in the length of the two rails. Considerable force will therefore be required to overcome the resistance due to the combined lateral and circumferential sliding of the wheels, so that more power will be needed to make them roll in a curve than is necessary to make them roll in a straight line. If, however, the axles are inclined to each other, then the wheels will naturally roll on a

Fig. 263. Fig. 264.

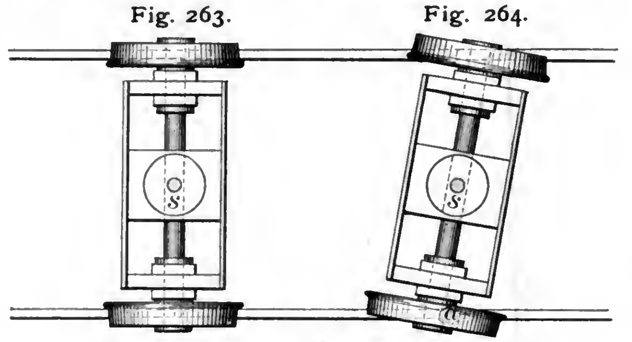
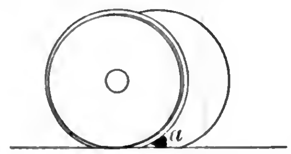


Fig. 265.



curved path, and it will not be necessary to slide them sideways to make them conform to such a path. But if the wheels are all attached to the axles, so that those on the same axle cannot turn independently of each other, and are all of the same diameter, then either the inside or the outside ones must slip, because the path in which the outside ones roll is longer than the inside curve, so that even if the axles are inclined to each other more power will be needed to roll the truck in a curved path than to roll the wheels shown in fig. 267 in a straight line. A cone or a portion of a cone, like that shown in fig. 269, will, however, of itself roll in a curved path. It will do the same thing if the middle is cut away, as indicated by the dotted lines in fig. 269 and in full lines in fig. 270. If now the wheels are made so that their peripheries* form portions of a cone and the axles are inclined to each other, as shown in fig. 271, then there will be no slipping on the track, because the outside wheel, being larger in diameter than the inside one, advances farther in one revolution than the latter does, and thus rolls on the longest path in the same time that the inside or smaller wheel does on the shorter one. When this is the case, such wheels will roll in a curve as easily as those in fig. 267 will in a straight line. The degree of inclination of the axles and of the sides of the cone must, however, vary with the radius of the curve. But if the axles are parallel to each other, and the wheels conical, as represented in fig. 272, they will not roll either in a straight line or in a curve without great difficulty, because if they roll in a straight line, the wheels on one side being larger in diameter than those on the other, either the larger or the smaller ones must slip on the path in which they roll. If they roll on a curve, then each pair of wheels has a

* The periphery is the outside surface on which the wheel rolls. This part of a wheel is usually called the "*tread.*"

tendency to roll in a curve independent of the other, and therefore the wheels must slip laterally, if both pairs roll on the same track. Thus, suppose two pairs of wheels, *a*, *a'* and *b*, *b'*, fig. 271, to be made conical and attached to a frame so that their axles are parallel to each other. Each pair of such wheels will then have a tendency to roll in circular paths, *a' i*, *a h*, and *b' k*, *b j*, the centers of which are at *m* and *n*, or at the apices of the cones of which their peripheries form a part. If they are wheels must be of unequal diameters and their axles be *radial** to the curve. This is equally true of any number of pairs of wheels. If we have three, four, or any number of axles, with wheels all attached to the same frame, if their axles are parallel, and the wheels of the same diameter, they will roll in a straight line; but if their wheels are conical and their axles radial, they will roll in a curve.

For the preceding reasons it is therefore sufficiently obvious

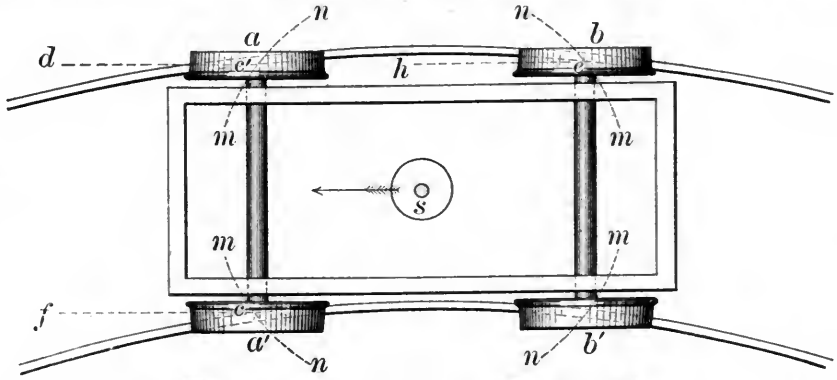


Fig. 266.

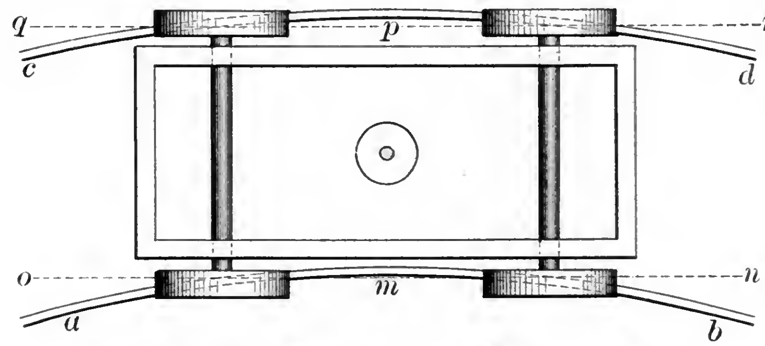


Fig. 267.

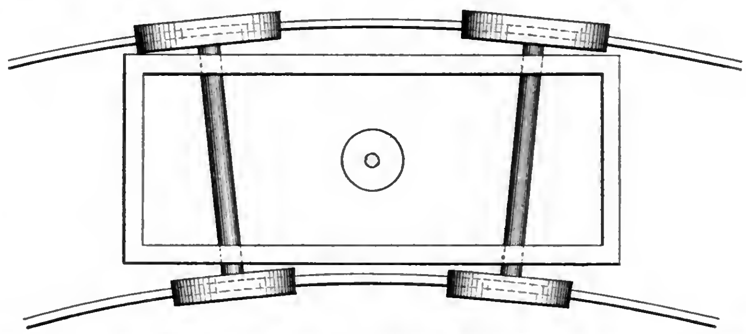


Fig. 268.

made to roll in circular paths, *c d*, *e f*, described from a center *g*, then each pair of wheels must slip laterally over the space between the paths *a' i*, *a h*, in which they would naturally roll and that in which they are made to roll. Thus the wheel *a* would slide laterally the distance between the curve *a h* and *a f*, and *a'* that between *a' i* and *a d*; *b* would slide from *b j* to *b f*, and *b'* from *b' k* to *b' d*. It will thus be seen that in order that two pairs of wheels may roll with equal ease in a straight line and in curves, the wheels in the one case must be of equal diameters and the axles parallel, and in the other case the

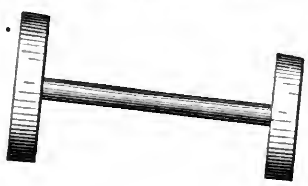


Fig. 270.

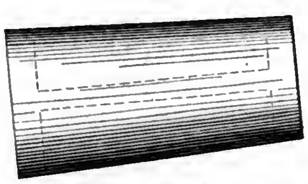


Fig. 269.

that if a locomotive is to run on both straight and curved tracks, on the former the wheels should be of the same diameter and the axles parallel, and on the latter the wheels should be conical and the axles radial.

QUESTION 430. *How are wheels made so that on curves they will act as though they were of the conical form described and on a straight track all be of the same diameters?*

Answer. The periphery or tread of each wheel is made conical, but of the same size as the other, and with the small diameters of the cones outside, as shown in fig. 273. The flanges

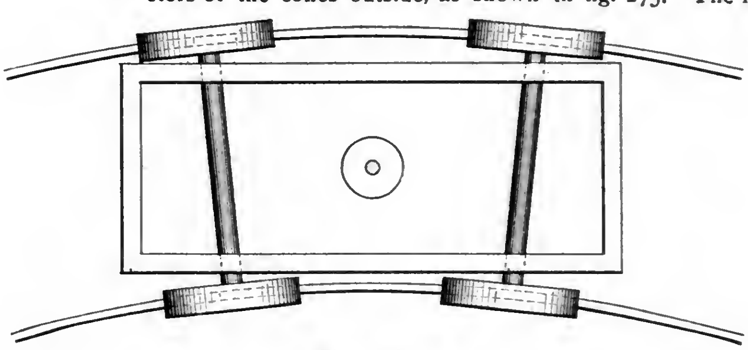


Fig. 271.

are then put closer together than the rails, so that there will be some space or end play, as it is called, between the flanges and the rails as shown at *s s'*. On a straight track, if the position of

* That is, that their center lines incline toward each other, and if extended far enough would meet at the center of the curve.

the wheels on the rails is such that their two flanges are equally distant from the rails, as shown in fig. 273, then obviously at the points of contact with the rails or on the lines *a* and *b* the wheels are of the same diameter. But in running on a curved track, the wheels, as has been shown, will roll toward the outer rail of the curve. The flange *c*—supposing it to be at the outside of the curve—will therefore roll toward the rail, and consequently the outside wheel will rest on the rail at a point nearer the flange, as shown in fig. 274, where the diameter *a* is larger, and the inside wheel *b* will rest on the rail at a point farther wheels to roll in a curve. It has also been proved by experiment that when the axles are parallel to each other the influence of the conical form of the wheels diminishes as the distance between the axles increases,* so that at the usual distance apart of the driving-axles of locomotives and of truck axles of locomotives and cars, the effect of the conical form of the wheels is almost, if not quite, inappreciable. Besides this, the conicity of the treads of wheels is rapidly worn away, so that it seems quite certain that the advantages resulting from coning-wheels are more imaginary than real.

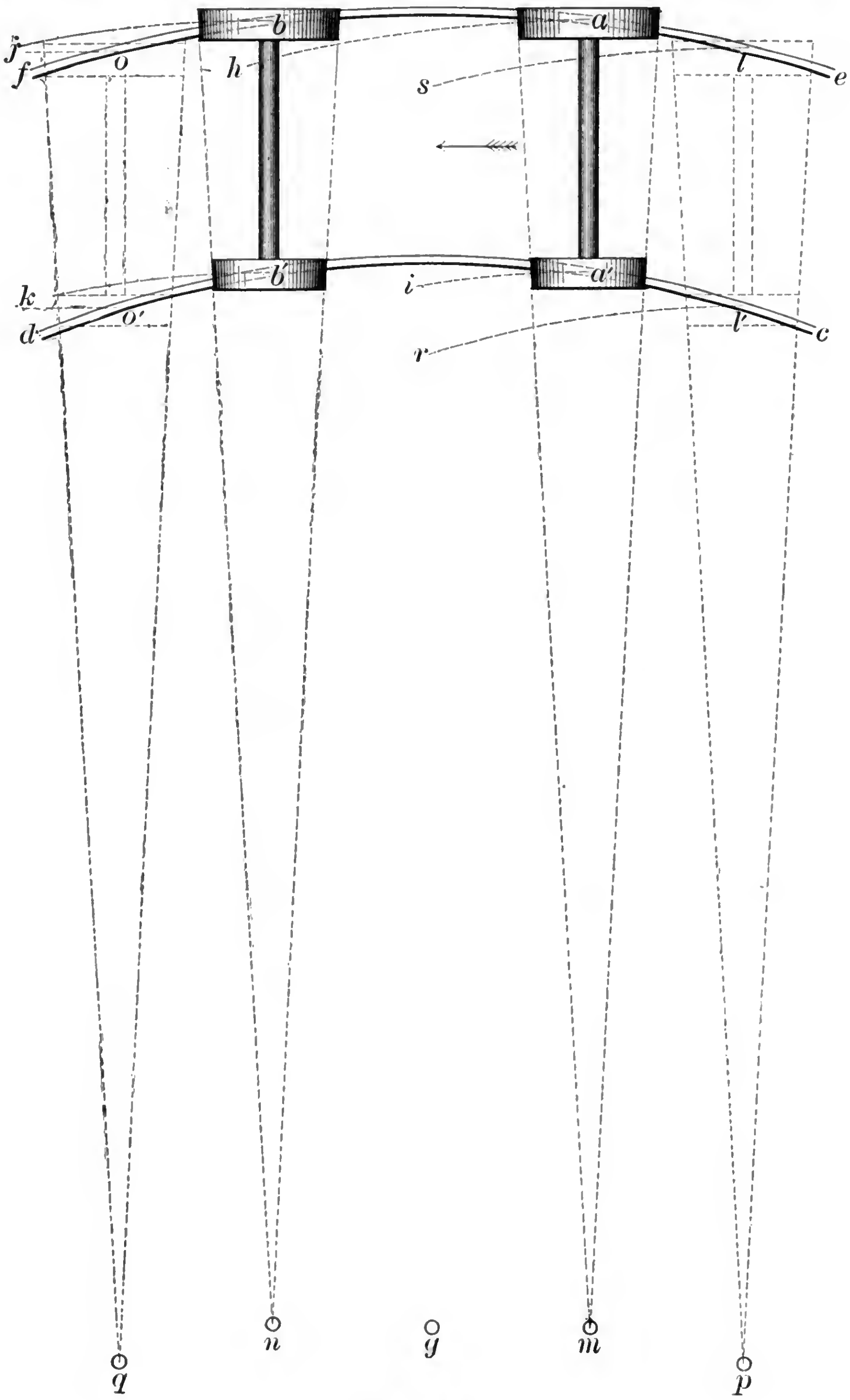


Fig. 272.

from the flange where the diameter *b* is smaller than at *a* and *b*, in fig. 273; and consequently the action of the wheels is the same as though their peripheries were made of the form shown in fig. 270.

QUESTION 431. *Does the conical form of wheels have much influence on their action on curves?*

Answer. No; for the reason that while the conical form of the wheels will cause a single pair on one axle to roll in a curved path, if the axles of two pairs of such wheels are held parallel to each other, as they are in a locomotive or truck frame, the conical form has very little influence to cause the

QUESTION 432. *Is the resistance to rolling diminished by placing the truck axles nearer together?*

Answer. It is within certain limits. The nearer each other they are placed, the closer will the center-pin of the truck be to the center of the axles. The closer it is to the center of the axles, the greater is the tendency of the wheels to become "slewed," or to assume a diagonal position to the rails as rep-

* This was shown in a paper read by the author at the annual convention of the Master Car Builders' Association, held in 1884, and which was published in the report of the proceedings of the convention of that year.

resented in fig. 264, which increases the resistance and also the danger of running off the track. The increase of resistance from this cause, after the axles reach a certain distance from each other, is greater than the decrease from a closer approximation to the position of radii. In ordinary locomotives it is necessary to place the truck wheels from 5 ft. 6 in. to 6 ft. 6 in. apart, in order to get the cylinders between them in a horizontal position. This distance apart works very well in ordinary practice.

shown, the lateral slip of the wheels is then greater than when they are nearer together. It is also obvious that if the wheels are parallel with the rails there will be no abrasive action of the flanges, but that the greater the angle at which the wheels stand to the rails the harder will the flanges rub against the rails, and the greater will be the flange friction. With the aid of geometry, it can very easily be proved that the farther apart two parallel axles are, the greater will be the angle of the wheels to the rails on a curved track, and therefore, the greater

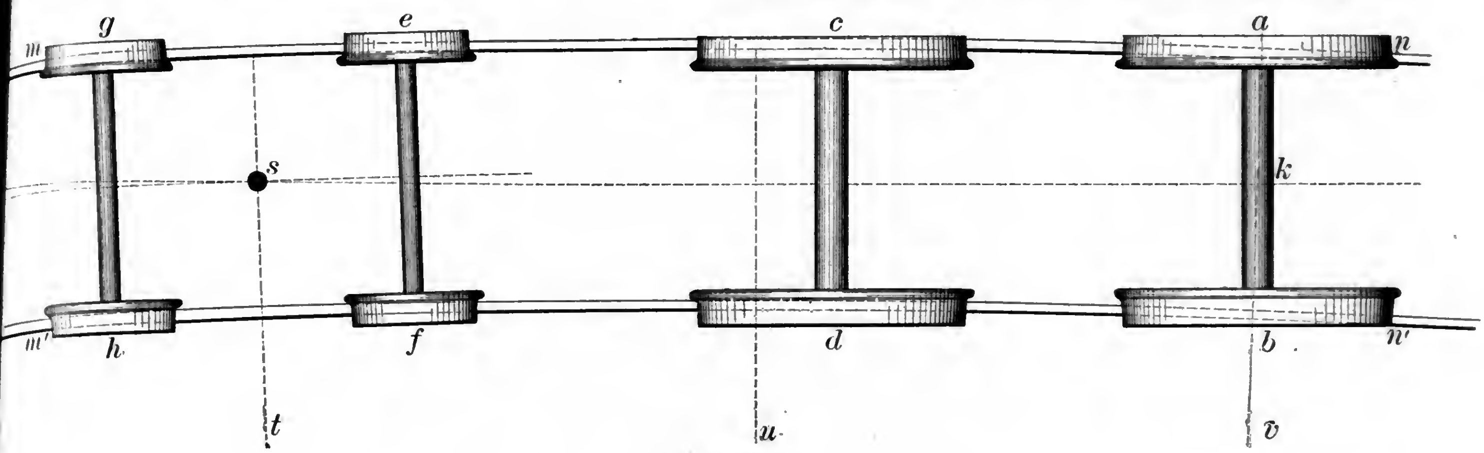


Fig. 275.

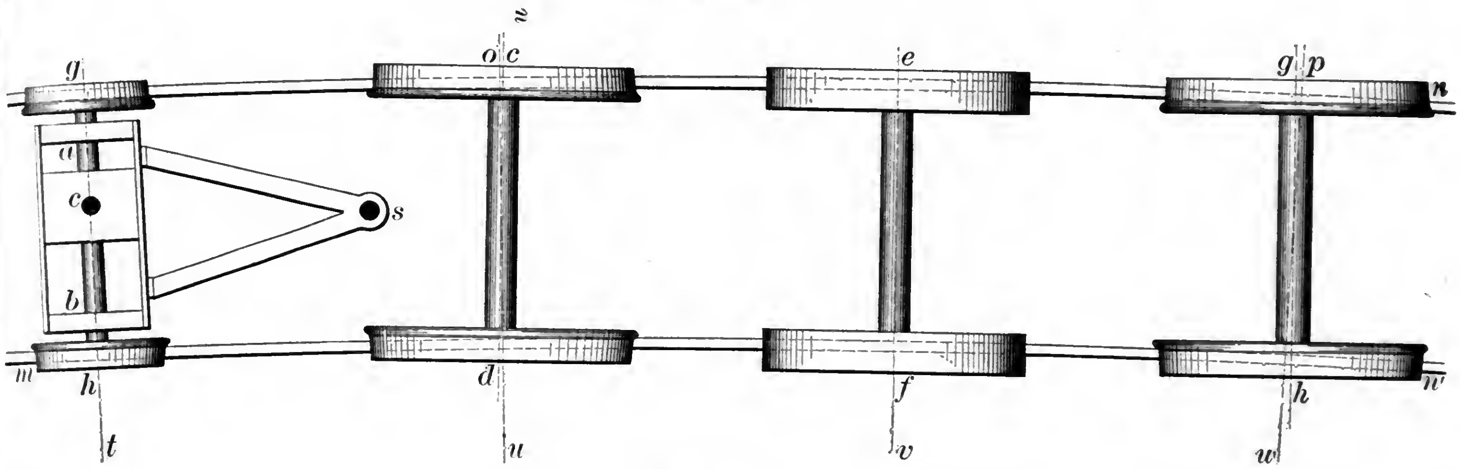


Fig. 276.

QUESTION 433. *What is meant by flange friction?*

Answer. It is the friction of the flanges of the wheels against the head of the rails. Thus if two pairs of wheels, *a*, *a'*, *b*, *b'*, fig. 266, be placed on a curve and rolled in the direction of the dart, the wheel *a* will roll toward the outside of the curve until the flange comes in contact with the rail. As already explained, if two axles are parallel to each other, no matter

Fig. 273.

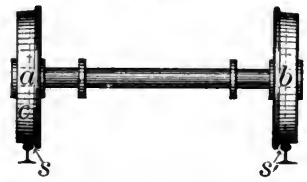
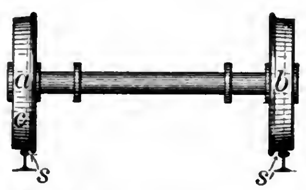


Fig. 274.



whether the wheels are conical or cylindrical, they must slip laterally in order to roll in a curved path. As the flange must follow the curve of the rail, it forces the wheel laterally, and thus compels it to roll in the curved path into which the rail is bent. As the wheel offers considerable resistance to sliding, there is a corresponding pressure of the flange against the rail, and consequently the revolutions of the wheel produce an abrasive action between the two. This action is obviously increased with the distance between the axles, because, as has been

will be their flange friction. It must, however, be remembered that if the wheels are so close together that they are liable to become "slewed," or assume a diagonal position across the rails, as shown in fig. 264, the angle at which the wheels would stand to the rails would thus be very much increased. It has therefore come to be a very generally recognized rule that the centers of axles should never be placed nearer together than the distance between the rails.

QUESTION 434. *Is the flange friction of all the wheels of a truck the same on any given curve?*

Answer. No; of the front wheels, *a a'*, fig. 266, obviously only the flange of the one, *a*, on the outside of the curve comes in contact with the rail. As the centrifugal force of the engine presses the back pair of wheels toward the outside of the curve, the flange of the outside wheel, *b*, alone comes in contact with the rail. But as this wheel is constantly rolling *away* from the rail, as shown by the dotted line *h b*, obviously the friction of its flange is less than that of the front outside wheel, *a*, which always rolls *toward* the rail. The flange of the back inside wheel, *b'*, is carried outward by the centrifugal force and also by the tendency of the outside wheel, *b*, to roll on its largest diameter on a curve, so that the flange of *b'* will not ordinarily touch the rail.

QUESTION 435. *How does a truck allow the axles of a locomotive to adjust themselves to the curvature of the track?*

Answer. The truck is attached to the locomotive by a flexible connection or center-pin, *s*, as shown in fig. 275 (which represents a plan of the wheels of an ordinary locomotive), from which it can be seen that the truck axles *e f* and *g h*, instead of remaining parallel to the driving-axles *a b* and *c d*, will, by turning around the center-pin, *s*, adjust themselves to the curve so as to approximate as closely to radii as is possible for two axles which are that distance apart and are held parallel to each

other. Of course, the farther apart they are the greater will be their divergence from the position of radii, and whether the tread of the wheels be cylindrical or conical, the farther apart their axles are the greater will be the divergence of the paths in which they would naturally roll from that of the curve of the track on which they must roll. Thus, if the axles were twice as far apart as they are represented in fig. 272, and in the position shown in the dotted lines *l l'* and *o o'*, the wheels, if they are conical, would then naturally roll in curves drawn from the centers *p* and *q*. If the wheels are cylindrical, they would roll in straight lines. In either case the divergence of their paths *l s* and *l' r* from the curve of the track is greater than *a h* and *a' i*, the paths in which they would roll if their axles were nearer together. This divergence increases with the distance

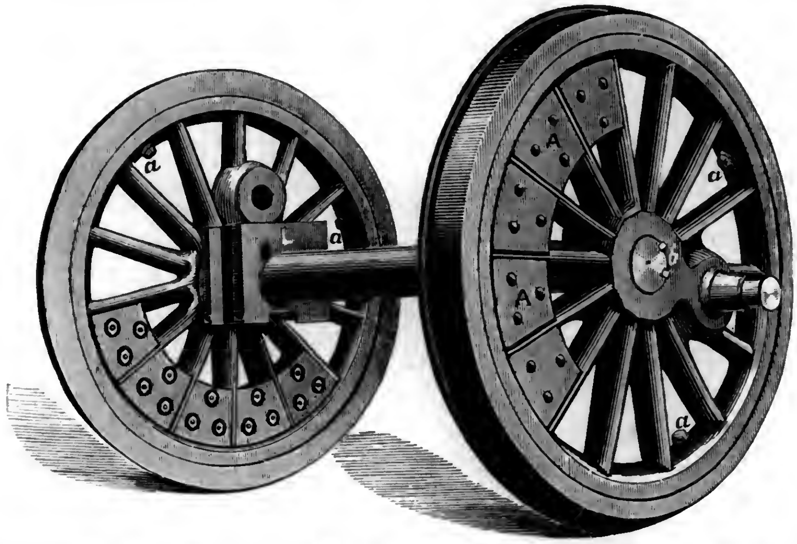


Fig. 254.

between the axles, and therefore the lateral slip of the wheels must be in the same proportion.

QUESTION 436. *How is a truck with a single pair of wheels arranged?*

Answer. The axle is attached to an A-shaped frame, shown at *a b s* in fig. 276, which is a plan of an engine with three pairs of driving-wheels and such a truck. The truck frame is connected to the engine by a pin, *s*, about which it can turn, and in this way the axle can adjust itself to the positions of the radii of the curve.

QUESTION 437. *Can the axles of driving-wheels assume positions radial to the track?*

Answer. In ordinary engines they cannot. Various plans have been devised for the purpose of enabling them to do so, but they have not met with much favor. It is, however, of less importance that the driving axles, when they are behind the center of the locomotive, should assume positions radial to a curved track than that the front wheels should. This is illustrated by a common road wagon, as all know the ease with which such a vehicle can turn a corner if we run it with the front axle ahead, and the difficulty of doing so when the back axle is in front. In the case of a locomotive, the reason for it is very much the same as that which makes the flange friction of the back wheels of a truck less than that of the front ones. From fig. 275 it will be seen that the outside driving-wheels, *a* and *c*, when the engine is running with the truck in front, are rolling *from* the rail and not against it. As stated before, the centrifugal force of the engine when in motion has a tendency to throw the wheels toward the outside of the curve. It will also be noticed that the front driving-axle is near the center of that portion of the curve which lies between the center, *s*, of the truck and the center, *k*, of the back axle. If it were in the middle, between them, it would be exactly radial to the curve; being near the middle, it approximates closely to that position, and therefore the flange friction of its wheels is very slight. It will be noticed that if the flange of the back or trailing-wheel, *b*, on the inside of the curve was not kept away from the rail, it would roll toward and impinge against that rail, and that the flange of the front driving-wheel, *d*, will come in contact with the inside rail before that on the back wheel can touch it. For this reason, and also on account of the effect of the centrifugal force exerted on the engine and the tendency of the wheels to roll on their largest diameters, the flange of the inside back wheel is kept out of contact with the rail, and as the back wheel, *a*, on the outside of the curve rolls away from the rail there is very little friction of the flanges of the back driving-wheels.

It will also be noticed from fig. 275, that if the radius of the curve is very short, the bend of the rails between the back pair of driving-wheels, *a b*, and the center of the truck is so great that the inside rail will press hard against the flange of the front or main driving-wheel, *d*, next that rail. This of course produces a great deal of friction, and if the curve is excessively short the flange will mount on top of the rail, and the tread of the opposite wheel will fall off from its rail. For this reason the center-pin of the truck is sometimes arranged so that it can move laterally—that is, crosswise of the track. The front wheels of locomotives are also sometimes made with wide "flat" tires—that is, tires without flanges, so that there will be no friction against the one rail and no danger of falling off of the other.

Another action also takes place which facilitates the motion of the driving-wheels of ordinary engines around curves. Every one knows how easily the direction in which the front wheels of a common wagon move can be controlled by taking hold of the end of the tongue or pole. With the leverage which it gives, the wheels and axle can easily be directed wherever it is desired. A similar action takes place in an ordinary locomotive. The front driving-axles are guided by the truck, which is attached to the locomotive frames ten or twelve feet in front of the driving-axle, and thus the truck exerts a leverage to guide the movement of the driving-axles, just as a common wagon can be guided by the pole.

If the locomotive is run backward, then none of these advantages exist, and the flange friction of the back driving-wheels is excessive. Engines, such as construction locomotives, which

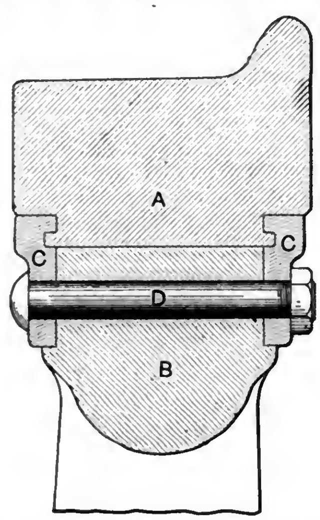


Fig. 277.

run backward as much as forward wear out the flanges of the back wheels very rapidly on crooked roads.

QUESTION 438. *What is meant by the "spread" of the wheels or axles?*

Answer. It is the distance between the centers of the axles.

QUESTION 439. *What is the "wheel-base" of a locomotive?*

Answer. It is the distance between the centers of the front and back or trailing-wheels. On ordinary engines, such as that illustrated in Plate III, it is the distance from the center of the front truck to the center of the back driving-wheels.

QUESTION 440. *How are the driving-wheels of locomotives constructed?*

Answer. In this country they are made of cast iron with

wrought-iron or steel tires around the outside. Fig. 254 represents a perspective view of a pair of locomotive wheels and axle. The central portion of the wheel—that is, the hub, spokes, and rim, are cast in one piece. Usually the hub and the rim, and sometimes the spokes, are cast hollow. The central portion of the wheel—that is, the part which is made of cast iron, is called the *wheel-center*. In Europe the wheel-centers are generally made of wrought iron.

QUESTION 441. *How are the tires fastened on the wheel-centers?*

Answer. The insides of the tires are usually turned out somewhat smaller than the outside of the wheel-center. The tire is then heated so that it will expand enough to go on the center. It is then cooled off, and the contraction of the metal binds it firmly around the cast-iron part of the wheel. As an additional security, bolts or set-screws, *a*, *a*, fig. 254, are screwed through the rim and into the tire to prevent it from slipping off in case it becomes loose.

QUESTION 442. *How are tires held on the wheels in case the former break?*

Answer. In Europe and on some railroads in this country the tires are fastened to the wheel-centers by what are called retaining rings. Fig. 277 represents a section of a tire fastened in this way. The fastenings consist of flat rings, *A A*, which are placed on each side of the wheel and tire and fastened with bolts, *D*. The rings have annular projections, *C C*, which fit into corresponding grooves in the tires. In case the tire should

Fig. 278.

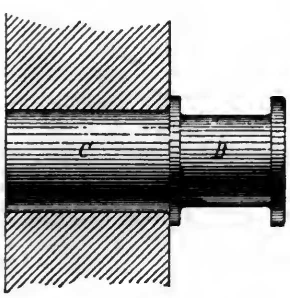


Fig. 279.

break, these rings hold it on in its position, and thus prevent an accident.

QUESTION 443. *Are there any standard sizes for the inside diameters of tires?*

Answer. Yes. To avoid the great inconvenience arising from the diversity in the *inside diameters* of tires, the American Railway Master Mechanics' Association has recommended standard dimensions for the inside of tires and the outside of driving-wheel centers. These are given in the following table:

STANDARD DIMENSIONS FOR DRIVING-WHEEL CENTERS AND TIRES.

Outside Diameter of Wheel-Centers.	Allowance for Shrinkage of Tire.	Inside Diameter of Tires.
38 in.	0.040 in.	37.960 in.
44 "	0.047 "	43.953 "
50 "	0.053 "	49 947 "
56 "	0.060 "	55.940 "
62 "	0.066 "	61.934 "
66 "	0.070 "	65.930 "

QUESTION 444. *How are the driving-wheels fastened on the axles?*

Answer. The hubs are accurately bored out to receive the axles, and the latter are turned off so as to fit the hole bored in the wheel. The axles are then forced into the wheel by a powerful pressure produced either with a hydraulic or screw press, made for the purpose. In order to prevent the strain upon the crank-pins from turning the wheels upon the axle,

Fig. 280. Fig. 281.

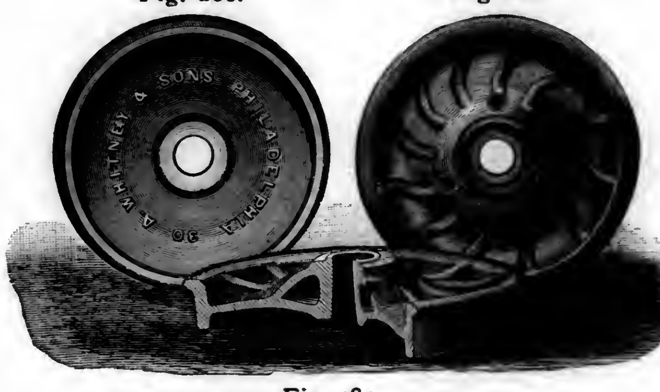


Fig. 282.

they are keyed fast with square keys driven into grooves cut in the axle and in the wheel to receive them. The ends of these keys are shown at *b*, fig. 254.

QUESTION 445. *How are the crank-pins made?*

Answer. They are made of wrought iron or steel and accurately turned to the size required for the journals for the connecting-rods. Fig. 278 represents one of the main crank-pins, and fig. 279 a back pin for an American engine. The main pin has two journals, one, *A*, to which the main connecting-rod is attached, and the other, *B*, receiving the coupling-rod. The back pin has only one journal, *B*, for the coupling-rod.

The collars on the crank-pins hold the rods on the pins.

QUESTION 446. *How are the crank-pins fastened to the wheels?*

Answer. They are turned so as to fit accurately into holes which are bored in the wheels. The holes are usually "straight" or cylindrical. The pins are then either driven in with blows from a heavy weight swung from the end of a rope, or else pressed in with a screw or hydraulic press. Sometimes the holes are bored tapered or conical and the pins turned to the same form. They are then ground in with emery and oil, so as to fit perfectly, and are secured by a large nut and key on the inside of the wheel.

QUESTION 447. *What are the pieces A, A, fig. 254, between the spokes of the wheel for?*

Answer. They are called *counterbalance weights*, or counterweights, and are put in the wheels to balance the weight of the crank-pins, connecting-rods, and pistons, as explained in Chapter XV.

QUESTION 448. *How are the truck wheels made?*

Answer. They are generally made of cast iron, usually in one piece. Figs. 280, 281 and 282 represent the most common form of cast-iron wheel which is used for locomotive and car trucks. Fig. 28 is a view of the front or outside of a wheel, fig. 281 of the back side, and fig. 282 is a wheel with a part of it cut away, so as to show a section of it. It will be seen that the plates which form the center of the wheel and the ribs on the back are curved in form. They are made in this shape so that when the

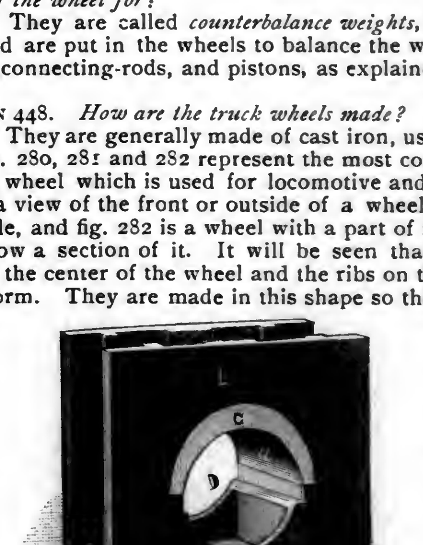


Fig. 284

wheel is cast and contracts in cooling, the plates and ribs can spring somewhat without being strained to a dangerous degree.

The tread of the wheel is hardened by a process called *chilling*. This is done by pouring the melted cast iron into a mould of the form of the tread of the wheel. The mould for the tread is also made of cast iron, but being cold cools the melted iron very suddenly, and thus hardens it somewhat as steel is hardened when it is heated and plunged into cold water.*

* It is only certain kinds of cast iron which will be hardened in this way, or will "*chill*," as it is called. The cause to which this chilling property is due is not known.

QUESTION 449. *What other kinds of wheels are used for car and locomotive trucks?*

Answer. A variety of wheels with steel tires are used for locomotive and car trucks. The wheel-centers are made of cast iron or wrought iron, or compressed paper held between two wrought-iron plates. The tires are fastened to the centers—or they should be fastened—with some kind of retaining rings.

QUESTION 450. *What is the shape of the tread and flange of a car and locomotive wheel?*

Answer. Fig. 283 represents the standard form for the treads and flanges of car and locomotive wheels which has been adopted by the Master Car Builders' and the Master Mechanics' Associations.

QUESTION 451. *On what part of the axle does the weight of the engine rest?*

Answer. It rests on what are called the *journals*, which are just inside of the wheels. These journals turn on brass bearings, called *journal-bearings*, which resist the friction of the revolving axle. The bearings are held in cast-iron or cast-steel boxes, called *journal-boxes*. One of these is shown at *L*, in fig. 254, and also separately, in fig. 284, in which *C* is the journal bearing and *d* the *oil cellar*. The latter is a receptacle underneath the axle which is filled with wool or cotton waste which is saturated with oil for the purpose of lubricating the journal. The oil-cellar is held in its position by two bolts, *f, f*, which pass through it and the driving-box casting. By removing the bolts the oil-cellar can easily be removed, and the box can then be taken off the axle.

QUESTION 452. *How are the boxes, journals, and journal-bearings of the truck wheels made?*

Answer. They are very similar to those for the driving-wheels, their chief difference being that those for the truck wheels are smaller than those for the driving-wheels.

QUESTION 453. *How are the frames for locomotives constructed?*

Answer. The frames, 32, 32, 32, Plates III, IV, and V, are made of bars of wrought iron from three to four inches thick and about the same in width. Each frame is usually made in two parts, the one at the back part of the engine, to which the driving-boxes and axles are attached, and the other at the front end to which the cylinders are bolted. The back part, or main frame, as it is called, is represented in figs. 285 and 286, and consists of a top bar, *H H*, to which pieces, *a, a', b, b'*, called *frame-legs*, are welded. Two of these form what is called a *jaw*, which receives the axle-box, as shown in fig. 286. To the bottom of each jaw a *clamp, c*, fig. 285, is bolted to hold the two legs together. The two legs, *a* and *b'*, are united by a brace, *d d*, bolted to the legs. A brace, *m*, unites the back end of the frame with the leg *b*, and is welded to each.

The front part of each frame consists of a single bar, *e*, which is bolted to the back end, as represented in figs. 285 and 286, which show the construction clearer than any description would. The front bar is shown plainly in Plates IV and V—the back end only is shown in figs. 285 and 286. These front bars extend forward to the front end of the engine, and a heavy timber, called a *bumper-timber*, extends across from one to the other and is bolted to each of them, as shown in Plates III, IV, and V. This timber is intended to receive the shock or blow when the locomotive runs against any object, such as a car. The *cow-catcher* or *pilot*, 38, 38, is fastened to this timber.

The front bar of the frames also has usually two lugs or projections forged on it, shown in Plate IV, between which the cylinders are attached. The latter are securely held in their position by wedges, which are driven in between the lugs and the cylinder castings.

The frames, as already stated, are in this country made of wrought-iron forged bars, and are accurately planed off over their whole surface. In Europe they are made of rolled-iron plates.

QUESTION 454. *How are the frames fastened to the boiler?*

Answer. As already stated, they are fastened to the cylinders with wedges and bolts, and as the cylinders are bolted to the smoke-box, the frames are thus rigidly attached to the front end of the boiler. In order to strengthen those portions of the frames which extend beyond the front of the smoke-box and to which the bumper-timber is attached, diagonal braces, shown in Plates III, IV, and V, are bolted both to the timber and to each of the frames at their lower ends. The upper ends are bolted to the smoke-box. Other braces are also fastened to the frames and to the barrel of the boiler. The frames are fastened to the fire-box by clamps, 10, 10, Plate III, called *expansion clamps*. These clamps embrace the frames so that the latter can slide through the former longitudinally. There are also usually two diagonal braces, shown in Plates III, IV, and V, the upper ends of which are fastened to the back end of the shell of the fire-box at about the level of the crown-sheet, and the lower ends to the back ends of the frames. Transverse braces are generally attached to the lower part of the frames, thus uniting the two together. The guide-yoke is also usually bolted to the frames and connected to the boiler.

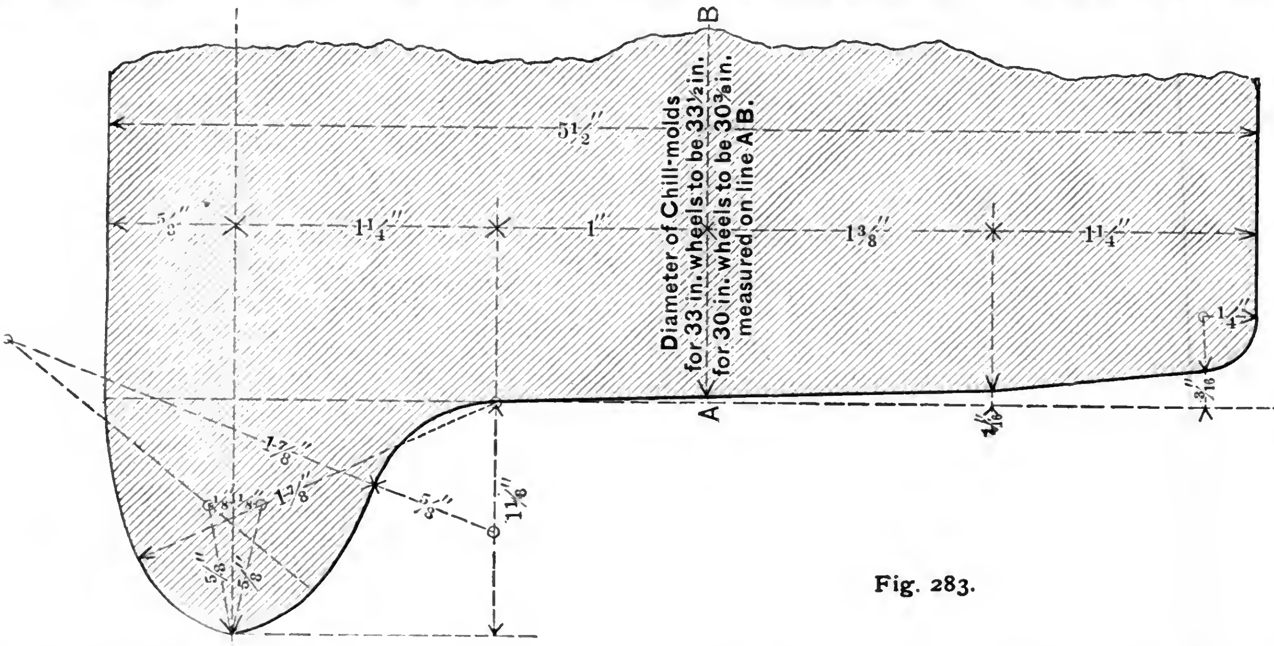


Fig. 283.

QUESTION 455. *Why are the frames attached to the shell of the fire-box so as to slide longitudinally through the fastenings?*

Answer. Because when the boiler becomes heated it expands, and if it could not move independently of the frames its expansion would create a great strain on both itself and the frames. The fastenings to the fire-box are therefore made so that the frames can move freely through them lengthwise, but in no other direction.

QUESTION 456. *How much more will a boiler expand than the frames in getting up steam?*

Answer. From ¼ to $\frac{5}{16}$ of an inch.

QUESTION 457. *Why is it necessary to support the engine on springs?*

Answer. Because,* however well a road may be kept up, there will always be shocks in running over it; these occur at the rail joints and especially when the ballasting of the ties is not quite perfect. These shocks affect the wheels first, and by them are transferred through the axle-boxes to the frame, the engine, and the boiler. The faster the locomotive runs, the more powerful do they become, and therefore the more destructive to the engine and road, and consequently the faster a locomotive has to run the more perfect should be the arrangement of the springs.

* This answer and much of the material referring to springs has been translated from "Die Schule des Locomotivführers," by Messrs. J. Brosius and R. Koch.

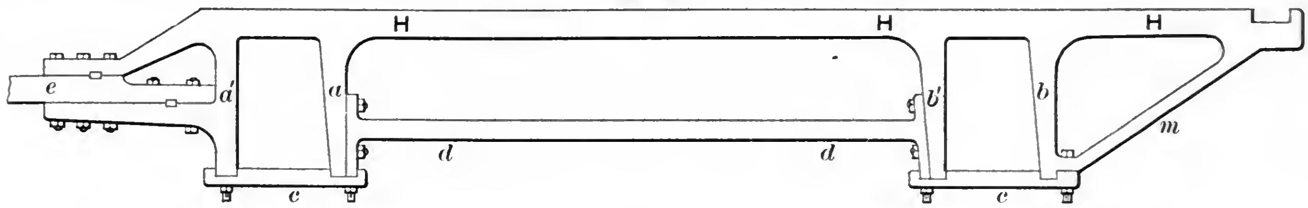
If we strike repeatedly with a hammer on a rail, the latter is soon destroyed, while it can bear without damage a much greater weight than the hammer lying quietly on it. The axles, axle-boxes, and wheels strike like a hammer on the rails at each shock, while the shock of the rest of the parts of the engine first reaches and bends the springs, but on the rails has only the effect of a load greater than usual resting on them. Another comparison will make still plainer the lessening by the

boxes slide against the faces of the shoes, thus wearing the shoe or wedge, but not the frame.

QUESTION 460. *Why is one or both of the shoes made wedge-shaped?*

Answer. They are made in that way so that when they become worn, by moving one or both of them up in the jaws, the space between them is narrowed and the lost motion is taken up. They are moved by the screws, *i, i*. If the boxes should

Fig. 285.



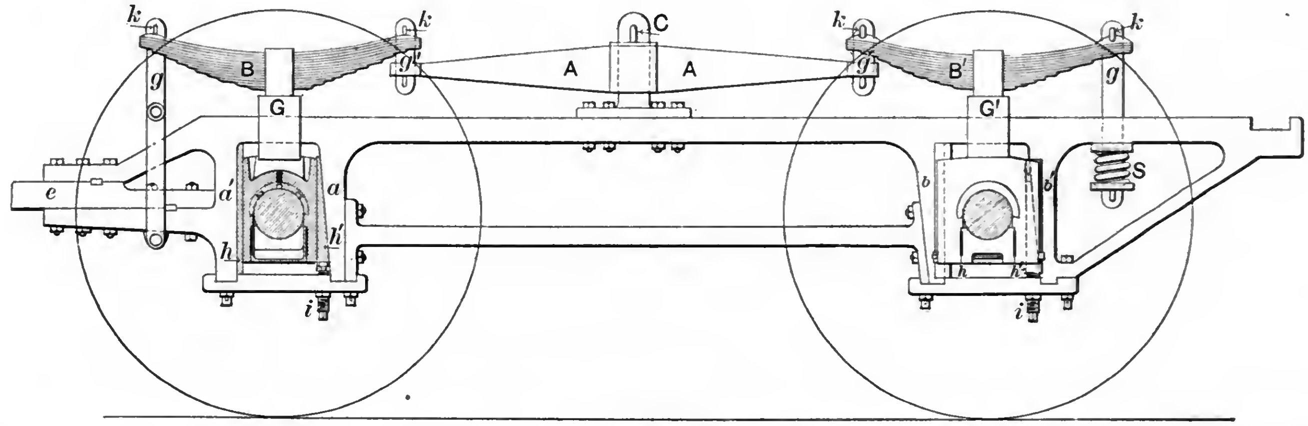


Fig. 286.

springs of the injurious effect which the weight of the boiler, etc., exercises on the rails.

A light blow with a hammer on a pane of glass is sufficient to shatter it. If, however, on the pane of glass is laid some elastic substance, such as india-rubber, and we strike on that, the force of the blow or the weight of the hammer must be considerably increased before producing the above-named effect. If the locomotive boiler is put in place of the hammer, the springs in place of the india-rubber, and the rails in place of the glass, the comparison will agree with the case above. From this consideration it will be seen how important it is to make the weights of the axles, axle-boxes, and wheels as light as possible.

QUESTION 458. *How are the driving-axle boxes arranged so that the weight of the engine will rest on springs?*

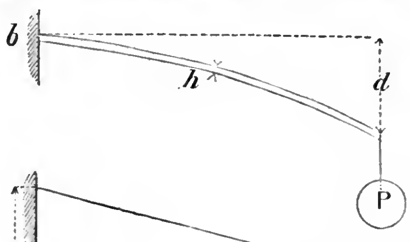


Fig. 287.

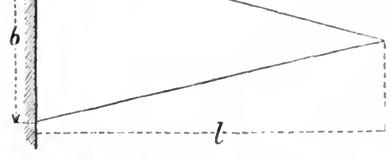


Fig. 288.

Answer. They are arranged so as to slide up and down in the jaws. Springs, *B, B'*, fig. 286, are then placed over the axle-boxes and above the frames. These springs rest on ∩-shaped saddles, *G, G'*, which bear on the top of the axle-boxes. The frames are suspended to the ends of the springs by rods or bars, *g, g', g, g'*, called *spring-hangers*. As the boiler and most of the other parts of the engine are fastened to the frames, their weight is suspended on the ends of the springs, which, being flexible, yield to the weight which they bear.

QUESTION 459. *How are the frames protected from the wear of the axle-boxes which results from their sliding up and down in the jaws?*

Answer. The insides of the legs, *a, a', b, b'*, are protected with *shoes* or *wedges*, *h, h'*, which are held stationary, and the

become loose from wear, it would cause the engine to thump at each revolution of the wheels or stroke of the piston.

QUESTION 461. *How are the springs for the driving-wheels made?*

Answer. They are made of steel plates, which are placed one on top of the other. These plates are of different lengths, as shown at *B, B*, in fig. 286, and are from 3 to 4 in. wide and $\frac{5}{16}$ to $\frac{7}{16}$ thick. The length of the springs measured from the center of one hanger to the center of the other is usually about 3 ft.

QUESTION 462. *What determines the amount which a spring will bend under a given load?*

Answer. The number of plates, their thickness, length and breadth, and of course the material of which they are made. This can be explained if we suppose we have a spring-plate of a uniform thickness, *h*. and a triangular form, of which fig. 287 is a side view and 288 a plan, and that it is clamped fast at its base, *b*. It is a well-known mechanical law that any material of this form and under these conditions will have a uniform strength through its whole length to support any load, *P*, suspended at its end, and also that it will bend or deflect in the form of an arc of a circle.

QUESTION 463. *How are locomotive springs usually made?*

Answer. In locomotives the arrangement of springs is always such that they are either supported in the middle and moved at the two ends, or such that they are supported at the two ends and loaded in the middle; for our consideration it is indifferent which of the two kinds of springs is taken for the present illustration. That shown in plan and elevation in figs. 289 and 290, which is formed of a wide plate placed diagonally, and which in reality consists of two such triangular pieces as were represented in fig. 288 united at their bases *m m*, fig. 290, and loaded at two opposite corners, *e* and *f*, would answer the requirements mentioned if the great breadth, *m m*, were not an obstacle. This breadth is obviated by cutting the spring into several strips, *a a, b b, c c, d d, ... i*, fig. 290, of equal width, and placing these not side by side, but one over the other, as shown in figs. 291 and 292.

In order that the separate strips and layers of the spring so made may not slip out of place, the strips *a a, b b*, etc., are made in one piece, and all the plates are enclosed with a strap, *F*, figs. 293–295. The plates, instead of being cut from a piece like that represented in fig. 290, are, however, made out of steel of the proper width, and the ends, instead of being cut off pointed as represented, are sometimes drawn out thinner on the ends, like the point of a chisel, or oftener still cut off straight, as shown in fig. 295.

The band, *F*, which is put around the middle, is put on hot, and becomes tight by contracting as it cools. The center of the spring has a hole drilled through it with a pin, *s*, fig. 294 (which shows a cross section of a spring), to prevent the plates from sliding endwise. The plates at each end usually have a depression, *a*, fig. 296 (which is a cross section of a plate on a larger scale than the preceding figure), made in them on one side, and a corresponding elevation, *b*, on the other. The elevation on one plate fits into the depression on the other, and thus prevents the plates from slipping sideways.

Fig. 289.

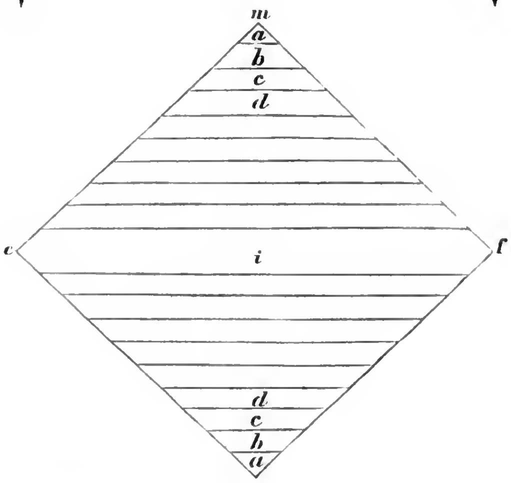


Fig. 290.

Fig. 291.

Fig. 292.

QUESTION 464. *How should springs be curved?*

Answer. Springs should be curved so that when they bear the greatest load which they must carry they will be straight. If they are curved too much they are subjected not only to a strain which bends the plates, but to one which has a tendency to compress them endwise. Thus if a spring like that represented in fig. 297 is bent into a half-circle, it is obvious that the strain at the ends has no tendency at all to bend the plates, but only to compress them endwise. Near the middle the strain

Fig. 293. Fig. 294.

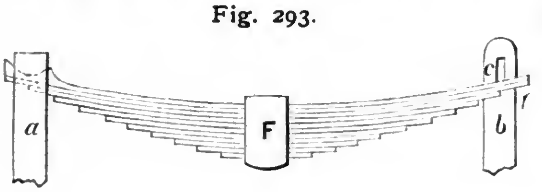


Fig. 295.

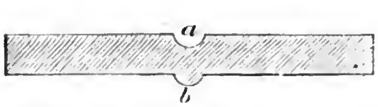


Fig. 296.

will, of course, bend the spring. In the one direction the spring is flexible and elastic, and in the other it is not; and as the strain of compression depends on the amount of curvature, the greater the latter is, the less flexibility and elasticity the spring will have.

Springs are often given a double curve, as shown in fig. 298. This is not to be recommended, because when a spring bends the plates must slide on each other. If they have but a single curve, they will do so and remain in contact through their whole length, but if they have two curves they will separate and therefore "gape," as it is called.

QUESTION 465. *What is the shape of the band on the spring?*

Answer. The bands are usually made of the form shown in fig. 293, but recently they have been made * of the form shown in fig. 299—that is, narrower on the under side than on top. This allows the lower and shorter plates to bend more than they could if held by a wider band, and gives them greater elasticity.

QUESTION 466. *What is meant by the elasticity of a spring?*

Answer. It is the amount which a spring will deflect or bend under a given load without having its form permanently changed. If the bending is so great that the spring does not recover its original form when the load is removed, then the strain to which it is subjected is said to exceed *the limits of elasticity*, and if repeated often it will ultimately break the spring.

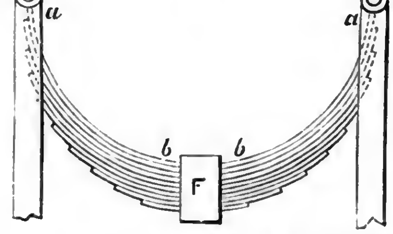


Fig. 297.

QUESTION 467. *What is meant by the elastic strength and the ultimate strength of a spring?*

Answer. The *elastic strength* is the strain it will bear without being strained beyond the limits of elasticity, and the *ultimate strength* is the strain which will break it.

QUESTION 468. *What determines the strength of a spring?*

Answer. It depends, of course (1), upon the material of which the spring is made; (2) its strength increases in proportion to the number of plates, and (3) to their width, and (4) in proportion to the square of their thickness, and (5) as the length diminishes.

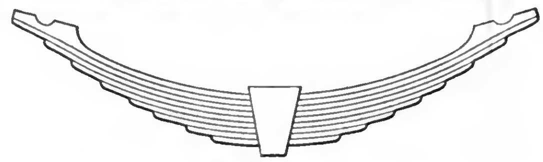


Fig. 299.

Thus, if we wanted to double the strength of a spring like that shown in figs. 287 and 288, it could be done in either of the following ways: (1) by making it of material twice as strong; (2) by putting another plate just like it on top; (3) by doubling the width of the base *b*, which would make the strength of the whole plate twice what it was before; (4) by making the whole plate about four-tenths thicker, which would increase its strength, as already stated, in proportion to the square of the thickness as $1.4 \times 1.4 = 2$ nearly; (5) by reducing the length to one-half what it is in fig. 287.

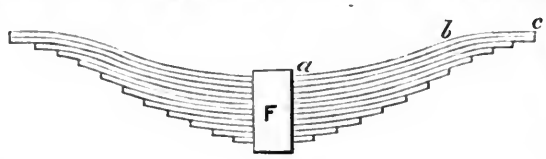


Fig. 298.

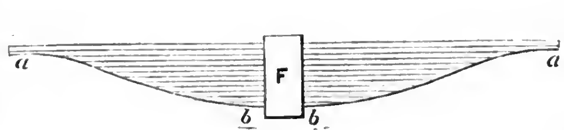


Fig. 301.

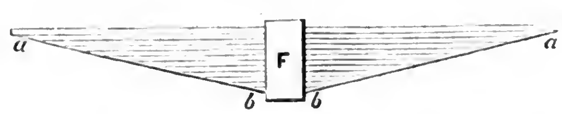


Fig. 300.

QUESTION 469. *What determines the elasticity of a spring?*

Answer. (1) The material of which it is made; with the same material the elasticity increases (2) as the number and

* By the A French Spring Company of Pittsburgh.

(3) as the width of the plates diminishes, and (4) with the cube of the length, and (5) decreases with the cube of the thickness of plate.

Thus, supposing the plate in figs. 287 and 288 to be ⅜ in. thick and the deflection d 2½ in.; the latter would be only half as much, or 1¼ in. (1), if it were made of material twice as stiff, or (2) with two such plates, or (3) with one twice as wide at the base. If (4) the length were doubled, the deflection would be equal to $2 \times 2 \times 2 = 8$ times what it was before, or in proportion to the cube of the length. If (5) the thickness were doubled the deflection would be *reduced* in the same proportion, and would be only one-eighth of 2½ in., or $\frac{5}{16}$ in.

QUESTION 470. *What should be the proportion of the plates of a spring in relation to each other?*

Answer. The lower plates should diminish regularly in their lengths. The reason for this will be apparent from the fact which has already been stated, that if a triangular plate of uniform thickness is clamped fast at its base, it will, if loaded at the end, be of uniform strength throughout its whole length. It is immaterial what the length of the base of such a triangle is; if the two sides are of equal length and the thickness of the plate is uniform, not only its strength, but the amount of deflection or bending from any load will be equal all through its length. If, therefore, we make a spring by cutting a plate formed of two such triangular pieces united at their bases into strips, as has already been explained, evidently the spring made of them will have a uniform strength throughout its whole length. As the strips thus made diminish in length regularly, it is evident that if the spring plates are made of steel rolled of the requisite width, their length should be the same as that of those cut from the plate referred to above. When this is the case, the lower outline, *a b b a*, fig. 300, of the spring will, when the spring is not bent, be straight lines. Sometimes the lower outline of springs is made curved, as shown in fig. 301. This gives too much stiffness between the middle *b b* and the ends *a a*. In drawing springs, therefore, it is best to lay them out with the plates straight, as shown in fig. 300, and after determining the thickness, drawing a straight line from a point near the strap to the end of the longest plate will give the best form of the spring and the length of each of the plates. It is necessary, however, to put a sufficient number of long plates in each spring to give it the required strength next to the attachment of the hanger. Sometimes one or more of these long plates are made thicker than the rest. The evil of this method of construction will be apparent if it is remembered that the greatest permissible deflection up to the breaking of the spring decreases with the *cube* of the thickness of the plate and its strength increases with the *square* of the thickness. Now if we have a spring with say ten plates ⅜ in. thick and one on top ¾ in. thick, the thick plate will have a strength *four* times that of the thin plates, but its elasticity will be only one-eighth that of the thin plates, and therefore it will require eight times as much load to bend it any given distance as is needed to bend the thinner plates the same distance. But its strength is only four times that of the thin plates, so that for any given amount of elasticity the thick plate must bear twice as much load as it has strength to carry. This shows what a great mistake is committed if some of the plates are made thicker than others, a conclusion which is supported by practical experience, as it is found that if the top plates are made thicker than others, the thick ones break most frequently, which is the necessary result of the supposed strengthening by increasing the thickness of the top plates.

QUESTION 471. **How can we find by calculation the elasticity or deflection of a given steel spring?*

Answer. BY MULTIPLYING THE BREADTH OF THE PLATES IN INCHES BY THE CUBE OF THE THICKNESS IN SIXTEENTHS, AND BY THE NUMBER OF PLATES: DIVIDE THE CUBE OF THE SPAN† IN INCHES BY THE PRODUCT SO FOUND, AND MULTIPLY BY 1.66. THE RESULT IS THE ELASTICITY IN SIXTEENTHS OF AN INCH PER TON OF LOAD.

QUESTION 472. *How can we find the span due to a given elasticity and number and size of plates?*

Answer. BY MULTIPLYING THE ELASTICITY IN SIXTEENTHS PER TON BY THE BREADTH OF PLATE IN INCHES, AND BY THE CUBE OF THE THICKNESS IN SIXTEENTHS, AND BY THE NUMBER OF PLATES: DIVIDE BY 1.66, AND FIND THE CUBE ROOT OF THE QUOTIENT. THE RESULT IS THE SPAN IN INCHES.

QUESTION 473. *How can we find the number of plates due to a given elasticity, span, and size of plate?*

Answer. BY MULTIPLYING THE CUBE OF THE SPAN IN INCHES BY 1.66; THEN MULTIPLYING THE ELASTICITY IN SIXTEENTHS BY THE BREADTH OF PLATE IN INCHES, AND BY THE CUBE OF THE THICKNESS IN SIXTEENTHS: DIVIDE THE FORMER PRODUCT BY THE LATTER. THE QUOTIENT IS THE NUMBER OF PLATES.

QUESTION 474. *How can we find the working strength—that is, the greatest weight it should bear in practice, of a given steel-plate spring?*

Answer. BY MULTIPLYING THE BREADTH OF PLATES IN INCHES BY THE SQUARE OF THE THICKNESS IN SIXTEENTHS, AND BY THE NUMBER OF PLATES; MULTIPLY, ALSO, THE WORKING SPAN IN INCHES BY 11.3: DIVIDE THE FORMER PRODUCT BY THE LATTER. THE RESULT IS THE WORKING STRENGTH IN TONS (OF 2,240 POUNDS) BURDEN.

QUESTION 475. *How can we find the span due to a given strength, and number and size of plate?*

Answer. BY MULTIPLYING THE BREADTH OF PLATE IN INCHES BY THE SQUARE OF THE THICKNESS IN SIXTEENTHS, AND BY THE NUMBER OF PLATES; MULTIPLY, ALSO, THE STRENGTH IN TONS BY 11.3: DIVIDE THE FORMER PRODUCT BY THE LATTER. THE RESULT IS THE WORKING SPAN IN INCHES.

QUESTION 476. *How can we find the number of plates due to a given strength, span and size of plates?*

Answer. BY MULTIPLYING THE STRENGTH IN TONS BY THE SPAN IN INCHES, AND BY 11.3: MULTIPLY, ALSO, THE BREADTH OF PLATE IN INCHES BY THE SQUARE OF THE THICKNESS IN SIXTEENTHS: DIVIDE THE FORMER PRODUCT BY THE LATTER. THE RESULT IS THE NUMBER OF PLATES.

QUESTION 477. *How can we find the required amount of curvature or set of the spring before it is loaded?*

Answer. BY MULTIPLYING THE ELASTICITY, PER TON, IN INCHES, BY THE WORKING STRENGTH IN TONS; ADD THE PRODUCT TO THE DESIRED WORKING COMPASS. THE SUM IS THE WHOLE ORIGINAL SET, TO WHICH AN ALLOWANCE OF ½ TO ⅝ IN. SHOULD BE ADDED TO THE PERMANENT SETTING OF THE SPRING.

QUESTION 478. *How are the spring-hangers attached to the ends of the springs?*

Answer. A great variety of methods have been used. The most common ones are those shown in fig. 286, in which the hangers consist of single bars which pass through openings or *eyes* in the ends of the springs, and have keys, *k k*, which bear on top of the springs. Sometimes the hangers are made to embrace the ends of the springs, as shown at *a a*, figs. 293 and 295.

The springs have projections forged on their ends to receive the keys in the upper end of the hangers, which are made to fit the grooves formed between the projections.

QUESTION 479. *How are the lower ends of the hangers held?*

Answer. The front hanger, *g*, fig. 286, of the front spring, and the back hanger, *g*, of the back spring are attached to the frame as shown. Sometimes a coiled or rubber spring, *S*, is interposed between the hanger and the frame to give more elasticity. The hangers *g' g'* are attached to the ends of a lever, *A A*.

(TO BE CONTINUED.)

* The following rules for calculating the proportion and strength of steel springs are from Clark's Railway Machinery.

† The span is the distance between the centers of the spring-hangers when the spring is loaded.

Manufactures.

Cars.

THE United States Rolling Stock Company now employs 600 hands at its shops in Anniston, Ala., turning out about 12 freight cars a day. A new wood-working shop 105 by 1,500 ft. is nearly completed.

THE Roanoke Machine Works at Roanoke, Va., has closed a contract for building 1,000 box cars and 2,000 dump cars for the Central Railroad Company of Georgia. The cars are to be of 60,000 lbs. capacity.

THE Harlan & Hollingsworth Company in Wilmington, Del., has just completed a car specially designed and arranged for carrying valuable race-horses. It is the property of Mr. John A. Morris, of Westchester, N. Y.

VESTIBULES are being applied to the cars on through fast trains of the Baltimore & Ohio Railroad as rapidly as possible at the Mount Clare shops. The first of these vestibule trains was put into regular service between Baltimore and Chicago, August 20.

THE Kansas City Car & Wheel Company is running its shops on orders for 100 coal cars for the Kansas City, Fort Scott & Memphis Railroad, 160 ore cars for the Union Pacific, and a number of smaller orders.

THE Barney & Smith Manufacturing Company in Dayton, O., has recently completed four passenger cars for the New York, Susquehanna & Western and 300 coal cars for the Kansas City, Fort Scott & Memphis.

J. G. Brill & Company, in Philadelphia, have received an order for 125 cars for the new Mexican Interoceanic Road.

The Norfolk Southern Railroad Company has added to its rolling stock 50 iron platform cars of 40,000 lbs. capacity.

The Hainsworth Steel Company has been organized in Pittsburgh for the purpose of manufacturing rolled cast-steel car wheels, under the process recently patented by Mr. William Hainsworth, Superintendent of the Pittsburgh Steel Casting Company.

The Pennsylvania Company has recently equipped at its Fort Wayne shops a train of stock cars, for the purpose of giving engineers and freight trainmen instruction in the use of air-brakes. This train will be run over the company's lines, stopping at all division points long enough to give proper instruction. The engine is equipped with an ordinary three-way cock, engineer's brake-valve, and engineer's brake-valve with equalizing port, the valves being connected with the train-pipe so that any one of them can be used in applying the brakes; in this way engineers become familiar with the use of the three different valves.

The cars, 25 in number, are equipped with Westinghouse freight brakes with quick-acting valve. While in use as a school this train will be under the charge of W. W. Todd, General Car Inspector for the company.

A New Screw-Power Testing Machine.

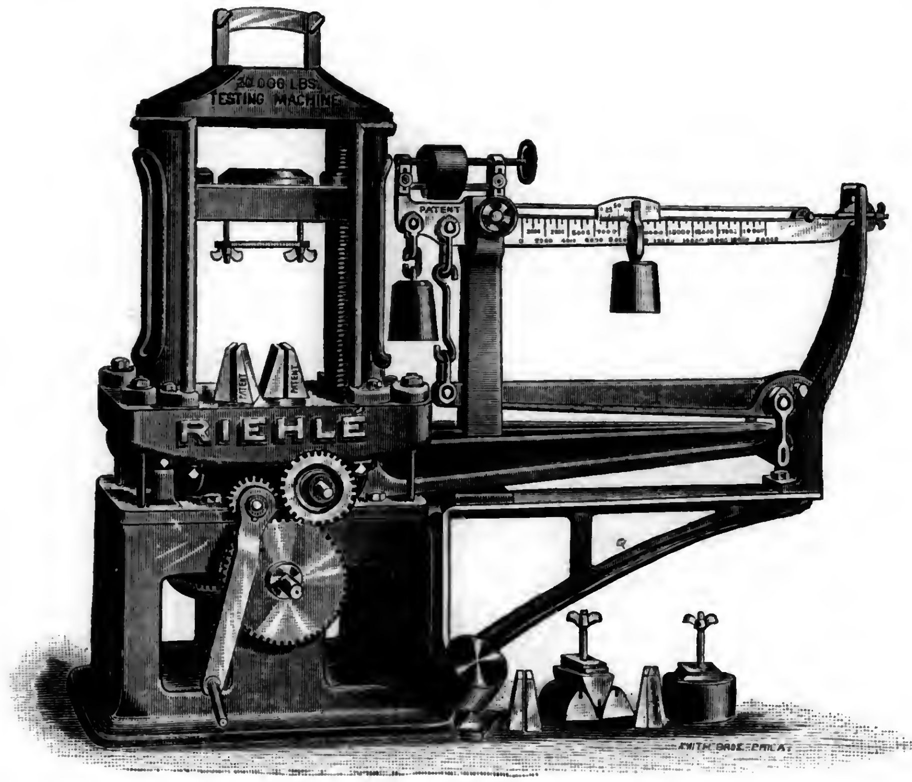
The accompanying illustration represents a new screw power testing machine for ascertaining the strength of metals and other materials under tensile, transverse, or compression strains, combining the elements of accuracy, speed, and facility of handling. The machine is constructed of the best materials, and the levers adjusted to the standard weights of the United States Government. There are three different speeds for testing a specimen and also for driving in the opposite direction. This allows of all the possible requirements of a wide range of material. There are no loose weights, and a single traveling poise, operated by a light hand-wheel, registers the strain accurately by means of a vernier. The power is applied by a crank with loose sleeve handle.

Tools are furnished with the machine for making the various tests, and there are stops and holders for the grips, etc., as well as bolts and cushions for checking the recoil and keeping the platform in place. The levers are arranged in tandem style, so that the machine will take up as little room as possible and allow a clear deck for transverse tests.

As the size of this compact machine is not very great, it is advisable to mount it on a solid wooden platform, from 16 to 18 in. high, so as to bring the crank and beam to a convenient working height, and made to suit the size of the machine base.

The crank can be slipped on any of the three key-end shafts, and thus secure three changes of speed in testing. On stopping the crank the machine will maintain the pressure on specimen as long as desired.

This style of machine is being built in the following sizes: 10,000 lbs., 20,000 lbs., 30,000 lbs., 60,000 lbs., 100,000 lbs., and 200,000 lbs. capacity, and can be built of increased capacity if desired. The 20,000-lbs. machine, which is the size shown in the engraving, is, in extreme dimensions, 4 ft. 6 in. high, 5 ft. 6 in. long, and 1 ft. 9 in. wide; its weight is 1,400 lbs. It will take in tensile specimens 1 ft. long, with 30 per cent. elongation, transverse specimens up to 15 in. long, and compression up to 10 in. long. The motion of the pulling head is 17 in.



IMPROVED SCREW-POWER TESTING MACHINE.

These machines are made by Riehle Brothers, of No. 413 Market Street, Philadelphia.

Locomotives.

The Canadian Pacific shops in Montreal are building a number of 10-wheeled passenger engines with 18 by 22-in. cylinders for use on the mountain section of the road.

H. K. Porter & Company, Pittsburgh, recently built a new passenger engine for the Castle Shannon narrow-gauge road.

Struthers, Wells & Company have begun the manufacture of locomotives for logging railroads at their shops in Warren, Pa. These locomotives will be of a design patented by W. L. Sykes of that place.

The Pittsburgh Locomotive Works are building several very heavy engines with 19 by 28-in. cylinders and 59-in. drivers for the Calumet Terminal Railroad Company of Chicago.

The Rhode Island Locomotive Works recently delivered four 10-wheeled engines with 18 by 24-in. cylinders to the Southern Pacific Company. They are intended for the Oakland local passenger service of the Central Pacific Road.

The Cooke Locomotive Works are making preparations to build new shops in Paterson, being unable to make proper arrangements for the extension of their business on the present site. The new shops will be much more conveniently placed

than the old ones, as the company will have plenty of ground, and the shops can be connected with both the Erie and the Delaware, Lackawanna & Western roads by sidings or spur tracks, thus avoiding the slow and expensive hauling which is necessary in their present situation.

Blast Furnaces of the United States.

THE *Iron Age* gives the following statement of the condition of the blast furnaces on September 1 :

	In Blast.		Out of Blast.	
Fuel.	Furnaces.	Weekly capacity.	Furnaces.	Weekly capacity.
Anthracite coal	92	33,541	94	21,674
Bituminous coal and coke	133	81,082	74	33,895
Charcoal	67	11,243	109	10,004
Total	292	125,866	277	65,573

The total weekly capacity of the furnaces in blast was 7,101 tons less than on September 1, 1887, but there was an increase of 6,577 tons in capacity during the month of August.

Manufacturing Notes.

THE McLeod Railway Signal Company, of Boston, has purchased property and is building shops at Canton, O., for the manufacture of its signals.

THE Martin Anti-Fire Car Heating Company, of Dunkirk, N. Y., recently placed an order for a large number of reducing valves with the Mason Regulator Company, of Boston.

THE Aluminium Brass and Bronze Company was recently organized at Waterbury, Conn., for the manufacture of bronze from aluminium and other alloys. Mr. Charles S. Morse will be the General Superintendent. The supply of aluminium will be supplied from Cowles's furnaces at Lockport.

THE Lookout Rolling Mill at Chattanooga, Tenn., is now running iron bars 100 ft. long, and is making arrangements to turn out bars up to 130 ft. in length.

THE Bethlehem Iron Company, Bethlehem, Pa., recently filled an order for steel rails weighing 90 lbs. per yard for the Philadelphia & Reading Company ; they are to be used in that company's passenger yard in Philadelphia.

THE Atlanta Bridge & Axle Company in Atlanta, Ga., has taken the contract to build a new four-span iron bridge over the Muscogee River for the Central Railroad of Georgia.

D. W. C. CARROLL & Co., of Pittsburgh, have closed a contract for the erection of two iron viaducts for the city of Denver, Col., to cross the railroads, which all center in one part of that city. One viaduct is to be 376 ft. long and 32 ft. high, and the other 785 ft. long and 32 ft. high. The viaducts are to be made of structural iron, including the approaches. They will be of sufficient width to allow of a driveway and two footpaths.

THE Penn Bridge Works at Beaver Falls, Pa., have a number of contracts for small bridges, and are making the iron roof for the Government buildings in Rochester, N. Y.

THE Keystone Bridge Company has taken the contract for a large bridge or viaduct at St. Paul, Minn. It will extend from the end of the bridge over the Mississippi River across the flats to the top of the bluff, and will have about 20 spans, four of 250 ft. each, one of 170 ft., and the remainder varying from 90 to 40 ft. The bridge will be carried on iron piers, two of which will be 150 ft. high. The same company has taken the contract for building the new Polk Street Viaduct over the Chicago & Northwestern tracks in Chicago.

Electric Street Cars.

IT is announced that the Westinghouse Electric Company, Pittsburgh, is about to undertake the manufacture of electric motors for cars. The company has been engaged for some time in experimenting with tests of the new Tesla motor, and the results, it is understood, have been so favorable that its manufacture on a large scale will be undertaken.

THE Bentley-Knight Electric Railroad Company is building a conduit line for the West End Street Railroad Company of Boston. This line is to run from the Providence Station along Boylston Street around and pass through Trinity Square and the new Beacon Street extension to Brookline.

THE Thomson-Houston Electric Company has just arranged for the completion of a plant for street railroads in Seattle, Wash. Terr. ; the road is four and a half miles long. The same company has also contracted to build an electric line in Bangor, Me. This line is two miles long and will use the overhead conductor, operating 10 cars. The company is also arranging to equip with its motor street railroads in Des Moines, Ia., Syracuse, N. Y., and Scranton, Pa., and is negotiating for the equipment of street lines at Lynn, Mass., besides several other lines.

Deoxidized Copper.

THE advantages to be obtained by the use of copper as nearly chemically pure as possible are generally admitted, whether the metal be used as copper, or in the form of brass, bronze, or the many other alloys into which it enters. The Deoxidized Metal Company, of Bridgeport, Conn., claims that the desired result is secured by the process which is used in its works. The castings of brass, bronze, etc., made under this process are most excellent, while the sheet copper and brass, and the wire made, when submitted to careful tests, show an unusually high degree of strength, copper wire having been tested up to 70,000 lbs. per square inch, tensile strength. The deoxided metal also possesses the property of great resistance to acids, so that it can be used for many purposes where ordinary metal is soon destroyed by the chemical action. Journal-bearings made from this metal have also been tested with very favorable results, while for bells it is claimed that the tone and quality is much superior to ordinary brass.

Southern Iron Production.

ALABAMA heads the list of Southern States in the production of pig iron, Tennessee and Virginia ranking next. The following table taken from the Baltimore *Manufacturers' Record* shows the relative position of some of the leading iron-producing States of the South, in tons :

	1880.	1887.	*Increase.*
Alabama	77,190	292,762	215,572
Tennessee	70,873	250,344	179,471
Virginia	29,934	175,715	145,781
Georgia	70,000	82,000	12,000
West Virginia	27,947	40,947	13,000

The chief increase has been in Alabama, Tennessee, and Virginia, comparatively small changes having taken place in West Virginia and Georgia.

A Model Steam-Heating Plant.

THE extensive works of the Russell & Erwin Manufacturing Company at New Britain, Conn., are heated by a very complete and compact plant, which was designed by and built under the supervision of Mr. T. S. Bishop, the Engineer of the Company.

This steam plant is entirely distinct from the other part of the works. The boilers are supplied with coal directly from iron cars which are run in on a track from the coal-yard, thus doing away with the necessity of a coal pile in the boiler-room, and insuring perfectly clean floors ; these cars hold about one ton each. The water is taken from a reservoir to the engine, and thence to the boiler feed-pumps ; from these pumps it passes through a feed-water heater, which consists of about 5,000 linear feet of 1-in. brass pipe placed in the smoke-flue to the main chimney. After leaving this heater the water passes through a settling drum, which allows the mud and other deposits to be drawn off at convenience. The discharge from the traps on the heating system in a large part of the works is also returned to the feed-pumps.

Where possible the steam mains or pipes are laid in trenches, which are covered with flag-stone to allow easy access for inspection and repairs. Lamp-black insulation is used for all pipes so laid. For heating the factory buildings an overhead system of piping is used.

The expansion joints in the mains are the variators devised by Charles E. Emery, of New York, for the New York Steam-Heating Company, and are placed from 90 to 100 ft. apart.

There are 10 boilers now in use, all of the horizontal tubular type, 6 ft. diameter and 17 ft. long, each boiler having 140 tubes 3 in. diameter and 16 ft. long. Two more boilers are to be added this year. These boilers were all made by Kendall & Roberts, of Cambridgeport, Mass.

The chimney to the boiler-room is 175 ft. high above ground, and 7 ft. internal diameter. The base of the stone-work at the surface of the ground is 21 ft. in diameter. This base is 6 ft. high, of rock-faced Portland sandstone. Above this the brick-work is circular, 18 ft. diameter for 10 ft., and is then surmounted by a cut stone water-table; upon this water-table the shaft rises in horizontal sections formed by two squares, making the section of the chimney an eight-pointed star; regular square brick can thus be used throughout. The top flares out considerably, and is surmounted by an iron cap 21 ft. diameter, and weighing about four tons. The chimney shaft has a batter throughout of about ¼ in. to the foot. The central core is of fire-brick, and there is a ventilating space of 4½ in. clear between this and the main walls of the chimney.

Provision is made against fire in the works by an independent fire apparatus consisting of two steam-pumps, with steam cylinders 20 in. diameter and 24-in. stroke, made by the Knowles Steam-Pump Works at Warren, Mass. These pumps are supplied with steam from two Herreshoff coil boilers. From these pumps 8-in. main pipes are laid through the streets around and between the various buildings, with numerous hydrants to which hose can be attached from two carriages always kept in readiness. There is a fire company, composed of the employés of the works, fully organized and equipped. This fire plant was designed by the Knowles Steam-Pump Company.

In order to provide against contingencies a special steam main is now being put down from the power boilers to the fire-pumps; when this is completed steam can be taken and the pumps started at any time, should an emergency arise, without delay, and without the necessity of keeping or starting fire in the special boilers.

Proceedings of Societies.

American Society of Civil Engineers.

THE first meeting of the season was held at the Society's house in New York, September 5, Vice-President Croes in the chair. A paper was read by Edward E. Magovern on the Theory of Aqua-Ammonia Engines, giving results of tests made on an engine of this type employed in running an Edison incandescent lighting plant.

The tellers announced the following elections:

Members: William James Baldwin, New York City; Elbridge Leonard Brown, Brockton, Mass.; Edward Bertie Codwise, Kingston, N. Y.; Walter Whaley Curtis, Fort Madison, Ia.; Arthur Powis Herbert, City of Mexico; Edward Maguire, Willett's Point, N. Y.; Arthur John Mason, Kansas City, Mo.; Charles Henry Nash, Bloomfield, N. J.; William Scherzer, Chicago, Ill.; William Humphrey Wightman, Palouse, Wash. Terr.

Associate—William Gibson, Jr., New York City.

Juniors—St. John Clarke, High Bridge, N. Y.; Walter H. Gahagen, La Salle, Ill.; Mason Delano Pratt, Johnstown, Pa.

AT the regular meeting of September 19 several written discussions of Colonel W. P. Craighill's paper on Improvement of Several of the Rivers of the Atlantic Coast were presented, and the paper was further discussed by members present.

New England Water-Works Association.

THE regular quarterly meeting, held in Cambridge, Mass., September 12, was the yearly field day. After a short business session a visit was paid to Harvard College, and the rest of the day was spent in visiting the water-works and the Fresh Pond and Stony Brook reservoirs. Lunch was served at the pumping station, and the members were entertained at dinner in the evening by the City Government.

Civil Engineers' Association of Connecticut.

THE summer meeeting was held in New London, August 22. The principal feature of the meeting was a paper presented by J. A. Monroe describing the engineering features of the new Thames River Bridge. After the reading of the paper the members of the Association inspected the work in progress on the bridge, and the meeting concluded with a sail around the harbor and a dinner.

Engineers' Club of Cincinnati.

AT the regular meeting, August 1, five active members were added. The report of the special committee, to which was referred communications from the Engineers' Club of Kansas City and the Western Society of Engineers in relation to State inspection of bridges, was submitted and approved by the Club. The report advocates the coöperation of engineering societies in favor of State inspection of highway and railroad bridges, and recommended the appointment of a standing committee to represent the Club. The Club, however, did not consider it desirable to establish any scale of minimum prices for preparing plans and specifications for bridges.

Colonel Anderson presented a paper on the Best Method for Establishing Points of Reference in City Surveying, in which he advocated the adoption of a method similar to that now in use in Philadelphia.

Western Society of Engineers.

THE 250th meeting was held in Chicago, September 5, Vice-President John W. Weston in the chair. Mr. Henry S. Maddock was elected a member.

After the reports of the Secretary and Treasurer, Mr. Weston, from the Committee upon Memoirs of Messrs. Baker and Latimer, submitted a report which was ordered printed.

The Secretary was instructed to forward paper with discussions upon Classification of Material in Railway Construction, for publication.

Mr. Rossiter called attention to the desirability of a translucent profile paper, suitable for blue printing, and thought that great improvement could be made in the standard papers used by engineers. After some discussion Messrs. Rossiter, Williams, and Parkhurst were appointed a committee to report on the question.

A paper by Mr. George Y. Wisner, upon Levels of the Lakes as Affected by the Proposed Lake Michigan and Mississippi Water-way, was read by the Secretary. After a short discussion the paper was laid over until the next meeting.

The report of Committee on Employment was made the special order for the next meeting.

Minneapolis Society of Civil Engineers.

AT the September meeting Mr. Cappelen read a paper describing the construction of the Northern Pacific bridge in South Minneapolis, in which he gave especial attention to the river bed, and incidentally spoke of the foundation of all the bridges across the river there.

Engineers' Club of Kansas City.

A REGULAR meeting was held in Kansas City, September 3. Walton Clark and Edmund Saxton were elected members.

A description of a new cable railroad grip was given by Mr. Harris.

This was followed by a note on Flood Waves of the Missouri River, by J. T. Wallace, and a letter referring to the Shrinkage in Earthwork from B. W. De Courcy, both of which were discussed by members present.

A number of additions to the library were announced.

New England Railroad Club.

THE first meeting for the season was held at the Quincy House, Boston, on the evening of September 19. According to the custom of this Club, this meeting was the annual dinner, and it was much enjoyed. About 125 members and guests were present, and after the dinner had been disposed of a number of speeches were made. An active season is promised for the Club.

Western Railroad Club.

THE first meeting of the season was held in Chicago, September 19. The following officers were chosen: President, G. W.

Rhodes; Vice-President, John Hickey; Treasurer, W. B. Snow; Secretary, W. B. Crossman.

Mr. Hickey read a paper on Circulation of Water in Locomotive Boilers, and Mr. W. Forsyth one on Material for Car Construction. Both papers were discussed.

It was resolved to hold the meetings on the Tuesday before the last Thursday in each month. Committees were appointed to arrange for reports of meetings and to secure permanent quarters.

Master Car and Locomotive Painters' Association.

THE annual convention was held in Cleveland, O., September 13 and 14, with a full attendance. A number of papers of much interest were read and discussed.

The following officers were elected for the ensuing year: President, Samuel Brown, Old Colony Railroad, Boston. Vice-Presidents, W. T. Hogan, Atchison, Topeka & Santa Fé, Topeka, Kan.; William Lewis, Grand Trunk, London, Ont. Secretary and Treasurer, Robert McKeon, New York, Pennsylvania & Ohio, Kent, O.

National Electric Light Association.

THE eighth semi-annual meeting of the National Electric Light Association begun at the Hotel Brunswick, New York City, August 29, the President of the Association, Mr. S. A. Duncan, of Pittsburgh, in the chair. After an address by the President, calling attention to statistics as to the amount of electric light apparatus in use in this country, Mayor Hewitt was introduced and delivered an address of welcome.

Mr. W. H. Harding, the Secretary and Treasurer, then presented his report, showing a net membership of 189, being a notable increase, and funds in hand of about $1,000.

The Committee on Insulation and Installation presented their report, enclosing schedule of data to be asked for from members. After some discussion the report was accepted and the committee continued.

A paper on Petroleum Fuel by Mr. S. S. Leonard, of Minneapolis, was read, calling attention to its advantages over other fuels. After a very interesting discussion the Convention adjourned until Thursday morning at 10 o'clock.

SECOND DAY.

Communications relative to the Paris Exposition of 1889 and the Centennial Exhibition at Cincinnati were received.

A committee was appointed to consider the recommendations embodied in the President's address and to report thereon.

Mr. S. S. Wheeler then read a paper on Overhead and Underground Wires in New York, followed by a short discussion on the cost of conduits.

In the afternoon the first paper was by Mr. E. G. Acheson on Disruptive Discharges and Their Relations to Underground Cables.

Mr. Alexander Crawford Chenoweth read the next paper, A Description of an Underground Conduit. On motion it was voted to appoint a committee to examine and report upon the underground wire question.

A communication from Mr. C. J. Field was read, inviting the members to inspect the lighting arrangements of the new Broadway Theater, also one from the Shultz Belting Company to inspect a belt at the East River Electric Company's station.

The revised constitution was then adopted.

THIRD DAY.

Mr. Frank Ridlon read the report of the Committee on Insurance Exchange, giving details of the methods pursued by the Boston Electric Exchange, and of the reduced rates granted by the New England Electric Exchange to licensees of the former.

Dr. P. H. Van der Weyde's paper was then read by Mr. Stewart on the Comparative Danger of Alternating *vs.* Direct Currents. The paper drew forth a brief discussion.

A paper on Some Methods of Electrical Measurements was read by Dr. G. A. Liebig, Jr., and then Mr. E. R. Weeks read a paper on Electrical Education, which was discussed.

Mr. H. L. Lufkin read a paper on a Basis from which to Calculate Charges for Electric Motor Service, which was discussed at some length by some of the members.

On Wednesday evening a large party was taken by the *Electrical Review* to Staten Island, to see "Nero."

On Friday evening a couple of hundred of the delegates left by the steamer *Catskill* for Providence, to take part in a clambake given on Saturday by the American Electrical Works and to proceed thence to Newport. The members then dispersed to their respective homes.

Roadmasters' Association of America.

THE sixth annual convention began in Washington, September 11, President J. W. Craig in the chair. The morning session was devoted to the election of members, reports of the officers, and other routine business. The Secretary reported 348 members, and 60 were added at this session. There were present at the meeting about 90 members.

The first business of the afternoon session was the report of the Committee on Standard Rail-Joints. Messrs. P. Nolan, A. B. Adams, and T. Hickey of the Committee offered the following:

"MAJORITY REPORT.—The undersigned, a majority of the Committee on Standard Track-Joints, beg leave to submit the following report: That the best device now known to them for a standard joint is the angle-bar. That this angle-bar should be from 42 to 44 in. in length, with slots for spikes 2 and 6 in. from the ends, with six bolt holes, spaced from 5 to 7 in. apart, resting on three ties, 9×7 in. and 8 in. apart, weight 50 lbs. per pair for a 60-lb. rail, and increased proportionately for increased weight of rail, shaped to conform to the head and flange of the rail, allowing about $\frac{3}{16}$ in. space between the splice and the web of the rail to permit of tightening. The cross-section of joint shown by fig. 6, page 28 of annual report for 1887, meets our views as to shape and fit. The bolt holes in both plates should be oblong in form, and round or button-head bolts be used. For rails weighing from 60 to 70 lbs. per yard a splice bolt $\frac{3}{4}$ in. in diameter, with a square nut of the proper size, should be used when practicable; and for rails weighing over 70 lbs. per yard a bolt $\frac{7}{8}$ in. in diameter of the same form should be used, and a metal washer or spring should be used between the nut and plate. As far as we now know we are in favor of giving the angle-bar, made heavy in the center and tapered toward the ends, a more extended trial before deciding on its merits over one of a uniform thickness throughout. That we decidedly prefer a supported joint to what is generally known as a suspended joint."

Messrs. R. Caffrey and H. D. Hanover of the Committee presented the following:

"MINORITY REPORT.—The undersigned, a minority of the Committee on Standard Track-Joints, submit the following report: That we still adhere to all the recommendations for a standard joint named in the report submitted at the Cleveland meeting in 1887; and we further say that it is our opinion and belief that a suspended joint having all the qualities named in that report, and in addition to be from 28 to 30 in. in length and having six bolts, has all the essential features required for a standard track-joint, and herewith submit blue prints of a section and side elevation of what we hereby recommend for a standard track-joint."

The discussion on these reports, which was joined in by many members, showed the usual wide difference of opinion in relation to the rail-joint question. Many experiences were given, but the general result seemed to be that no roadmaster was satisfied with the joints in use on his road.

SECOND DAY.

At the morning session the discussion of the reports on rail-joints was resumed; after a short time it was closed by the passage of a resolution referring both reports back to the Committee, with instructions to present a new report at the next convention. Roadmasters are also requested to make comparative tests of the supported joint and the heavy suspended joint under similar conditions of track and traffic.

The Committee on Snow and Snow-Plows presented its report, recommending the use of an iron snow-plow for ordinary snowfalls and the Rotary plow for very heavy snow. The use of snow-fences at exposed points was also recommended.

The Committee on Cross-ties presented a report, recommending for ballasted track ties 7 by 8 in., 8 ft. long, and for mud ballast or unballasted roads ties 7 by 10 in., 9 ft. long, 11 ties to be used for a 30-ft. rail. No recommendation was made with regard to metal ties or to the methods of preserving timber. This report called out some discussion, the objection being raised that it was now difficult on many roads to get 7 by 10 in. ties.

At the afternoon session the Committee on Standard Hand-cars presented a report, giving weights and dimensions, but not recommending any special pattern. This was adopted.

The Committee on Standard Frogs submitted a report, a letter was also read from the Superintendents' Association asking for an expression of opinion as to the relative merits of solid and spring-rail frogs; after some discussion the subject was carried over to the next annual meeting.

Several members then stated their experience with different processes for the preservation of ties.

The Committee on Labor on Track presented a report, which was discussed and then referred back, the Committee being continued.

A memorial of Mr. Charles Latimer was presented. It was resolved to hold the next annual meeting at Denver.

The following officers were then elected: President, J. W. Craig, Charleston & Savannah; First Vice-President, I. Burnett, Joliet Steel Works; Second Vice President, James Sloan, Chicago & Eastern Illinois; Secretary and Treasurer, H. W. Reed, Savannah, Florida & Western; Executive Member for three years, R. Black, Manhattan Elevated.

OBITUARY.

COLONEL GEORGE W. PERKINS, the oldest railroad officer in the United States, a notice of whom was published in our last number, died at Groton, Conn., September 5. He was 100 years and one month old, and had been Treasurer of the Norwich & Worcester Railroad Company for over 50 years.

RICHARD A. PROCTOR, the well-known astronomer and popular writer and lecturer on astronomy, died in New York, September 12, of yellow fever. He was born in Chelsea, England, in 1837, graduated from Cambridge University in 1860, and early became known as a lecturer. He first visited this country in 1873; some years ago he decided to settle here, and established his home and observatory near Orange Lake, Fla. At the time of his death he was on his way from Florida to England.

PERSONALS.

W. R. MICHIE is now Assistant Engineer of the St. Louis & San Francisco Railroad.

J. H. PEARSON is now Engineer in charge of the Georgetown Extension of the Louisville Southern Railroad.

J. J. TOMLINSON is now Master Mechanic of the Gulf, Colorado & Santa Fé Railroad, with office in Galveston, Tex.

F. L. PITMAN has been appointed Chief Engineer of the Atlantic & Danville Railroad, succeeding George S. Bruce, resigned.

JACOB JOHANN, late Superintendent of Motive Power of the Texas & Pacific Railroad, is at present residing in Springfield, Ill., his former home.

V. O. CASSELL has been appointed Assistant Engineer of the Atlantic & Danville Railroad, succeeding F. L. Pitman, who is now Chief Engineer.

GEORGE R. OTT has been appointed Master Mechanic of the Chicago Division of the Baltimore & Ohio Railroad, succeeding B. F. LOWTHER, who has resigned.

G. W. CUSHING, late Superintendent of Motive Power of the Philadelphia & Reading Railroad, has changed his address from Reading, Pa., to Box 278, Chicago, Ill.

J. EVANS has been appointed Master Mechanic of the Oregon Railway & Navigation Company, with headquarters at Dalles, Ore., succeeding H. Webber, resigned.

T. W. HEINTZELMAN has been appointed Assistant Superintendent of Motive Power of the Southern Pacific Company, with office in Sacramento, Cal.

GEORGE S. BRUCE, late Chief Engineer of the Atlantic & Danville Railroad, has resigned that position and has become a member of the new firm of Harper, Bruce & Co., engineers and contractors.

EDWARD D. BOLTON, C.E., of the firm of T. William Harris & Co., of New York, has been appointed Consulting Engineer for Asheville, N. C., in connection with the new sewerage system, upon which it is proposed to expend $100,000. JOHN G ASTON, City Engineer, will be Resident Engineer.

COLONEL T. M. R. TALCOTT has resigned the office of Commissioner of the Southern Railway & Steamship Association, to accept the position of First Vice-President of the Richmond & Danville Railroad. He is thoroughly familiar with that road, having been formerly connected with it for 16 years as Chief Engineer, Superintendent, and General Manager.

LIEUTENANT JACOB J. HUNKER has been designated by the President under the new law as Supervisor of the Harbor of New York. He is to act under the direction of the Secretary of War in enforcing the provisions of the act to prevent obstruction and injurious deposits within the harbor and adjacent waters of New York City by dumping or otherwise, and he is to detect all offenders against this act. He is to direct the patrol boats and other means to detect and bring to punishment offenders against the provisions of the act.

EZRA M. REED has resigned his position as Vice-President of the New York, New Haven & Hartford Railroad Company, and will retire from active work altogether. Mr. Reed entered the service of the Hartford & New Haven Company in 1843, and served as Master Mechanic and Superintendent of that road. After the consolidation by which the present company was formed he was made General Superintendent of the road, and some years later Vice-President also.

NOTES AND NEWS.

New White Star Steamers.—The White Star Line is having two new ships built at Harland & Wolf's shipyard at Belfast. One of them is named the *Majestic*, but the name of the other has not yet been made known. The length on the water line is 565 ft. and the width 52 ft. The vessels are to be propelled by twin screws, which overlap at the tips, the starboard screw being carried some feet further aft to get clearance.

Proposals for Submarine Torpedo Boat.—The Navy Department has decided to readvertise for contracts for the proposed submarine torpedo boat. The proposals will be received by the Department until January 4, 1889. The contractor must furnish a boat complete with torpedo fittings and appendages; it must be built of steel, of material manufactured in the United States, and must be of the best modern design. The proposals must be accompanied by drawings and specifications showing clearly what he proposes to build. Information for the general requirements to be made in the plans can be obtained on application to the Bureau of Ordnance Department.

Baltimore & Ohio Mechanical Reorganization.—In connection with the general reorganization of the Baltimore & Ohio management, President Spencer has appointed a Commission to examine thoroughly the shops, stationary machinery, and motive power of the road, and to report what reforms and improvements are needed in order to bring the machinery up to modern requirements, and to secure the best division of labor and concentration of work. The Commission will visit all the shops of the company, and also those of several other leading companies. At the head of the Commission is Mr. M. N. Forney, of New York, the other members being all officers of the company, as follows: A. J. Cromwell, Superintendent Motive Power of the Lines East of the Ohio River; J. N. Kalbaugh, Master of Machinery, Pittsburgh Division, and E. L. Weisgerber, Master of Machinery of the Ohio Division.

An Individual Heater.—An exchange says that a portable steam heater has recently been invented by a Bridgeport man, consisting of a copper boiler, under which is a diminutive lamp, encased in a nickel box, and balanced something like a compass, so that, no matter what position the outside box is in, the boiler and lamp will always remain in the required vertical position. After the lamp is lighted, the water in the boiler is heated and circulated through rubber tubes, which run down the legs, around the ankles, up around the back, and back to the boiler. The circulation of the water keeps the body warm on the coldest day. Elaborate heaters are being constructed for ladies' wear, which can be worn inside the bustle and gauged so as to run eight or ten hours. A safety-valve is provided to prevent excessive pressure.

It cannot be denied that this apparatus promises comfort to cold-blooded people, but there are contingencies to be taken into account. To say nothing of the picturesque spectacle which a man would present with steam blowing off from the back of his neck, or a lady with the valve in her—well, bustle—in full blast, the contingency of a possible explosion must be taken into account, should the aforesaid safety-valve stick. Then, too, the apparatus might be comfortable in a car, but too much pressure, and the consequent escape of steam, might produce that high degree of humidity which we all dread in late summer; while in a collision it might be an open question whether 50 simultaneous little explosions might not do as much damage as one large one. As a compensation, however, lovers will urge that any suspicious sound heard while passing through a tunnel could be easily explained as the pop of a safety-valve, and ill-natured criticism thus prevented.

Russian Petroleum in Sweden.—Consul Ernest A. Man writes to the State Department from Gothenburg, Sweden, as follows:

"Russian petroleum is being advertised and introduced very

extensively in the market here. For some time past there have appeared daily in the newspapers advertisements in large type, offering Russian petroleum at retail at 29 öre ($0.077) per kanna (0.6915 gallons), and American petroleum at 35 öre ($0.093) per kanna, with the apparent object of attracting general attention to the lower price of the Russian oil. This makes a difference of but 6 öre or ($0.016) a kanna in favor of the Russian product, which amount, when reduced to United States currency, seems very small; but in Sweden the difference of 6 öre in purchasing a trifle over ⅔ gallon of oil would have as much, if not considerably more, influence on a buyer than a difference of 6 *cents* on a similar quantity would have in the United States.

"A storage tank of a capacity of 12,000 barrels has recently been erected on one of the small islands in the harbor below the city, and a tank steamer from Libau, Russia, has just brought and discharged a cargo of 7,000 barrels, and is now returning to Libau for a second lading. This is the first importation ever brought into this port in the above manner. This oil will be distributed through the medium of barrels collected in this locality, most of which are of American manufacture, to the obvious disadvantage of our petroleum interest. I am convinced that much of the strong-smelling oil that is already sold here as American oil never crossed the Atlantic. Although the difference in price between the two oils is slight, it would still prove a strong factor in driving the American oil—notwithstanding its acknowledged superiority—from the Swedish market, as there is probably no other country in Europe where economy is more rigidly practised or is more necessary. In this high latitude the expense of illuminating, instead of being distributed, as elsewhere, with comparative equality throughout the year, is condensed into six or seven months, when the other needs of a rigorous winter season fall with an accumulated volume upon the people."

Railroads of Southern Brazil.—At present there are three railroads in operation in the Province of Rio Grande do Sul, projected for which preliminary surveys have been made.

The lines in operation are the Rio Grande & Bage, opened for traffic on December 2, 1884; the Porto Alegre & Uruguayana, opened March, 1883, and the Porto Alegre & Novo Hamburgo, opened in 1875.

The Rio Grande & Bage road is substantially built; has a gauge of 1 meter, or 1.09 yards, and is laid with heavy T-rails, of English manufacture, on hard-wood sleepers, secured with spikes, and ends joined with fish-plates and bolts. It was built and is at present owned and operated by an English company. The locomotives are from the Baldwin Locomotive Works, of Philadelphia, of the Mogul pattern, burning Cardiff coal and patent fuel, which is simply very fine coal mixed with some resinous substance and pressed into hard blocks. Passenger coaches are of two classes. Those for the first-class passengers were made in the United States and on the American plan, and those for the second-class passengers were made in Europe, but on the same plan as the first-class coaches. The traffic, or freight cars are of Brazilian make, being light and short, mounted on a single truck at each end. It is expected to extend this road to the Brazilian boundary line.

The latest pubished official returns showing the receipts and expenses of the road, are for the year 1886, $329,645, and expenses, including improvements, $306,364, leaving an unexpended balance of $23,281.

The second road, when completed, will run from Porto Alegre, the capital of the province, in the central eastern part, to Uruguayana, on the Uruguay River, a distance of 378 miles. However, it is not completed over two-thirds of the way, the work of track-laying progressing slowly.

The third and last line in operation is a short one, 26 miles in length, connecting the capital with New Hamburg, a large German settlement. It is owned by an English company.

There is constant communication from Rio Grande do Sul to Rio de Janeiro by several steamship lines.

French Steam Navigation.—The directors of the French General Transatlantic Company have introduced a system of premiums or awards for economies realized in working expenses. The result has been that the company has secured appreciable reductions in respect of the cost of motive power, maintenance of ships, stores, etc. Careful attention has also been directed to what is styled the "Manutention service," so as to reduce the cost of labor and the outlay for tugs, lighters, etc. Every effort has been made to obtain the largest amount of work and service out of steamers comprising the company's fleet, and last year the 65 vessels of the fleet list made 1,206 voyages in the Atlantic and the Mediterranean, the aggregate distance traversed being 775.168 marine leagues. In this total the company's postal service figured for 487,694 marine leagues, and what are known as the "free services" of the company for 287,474 marine leagues. Careful attention has been given to obtaining stores and supplies of all kinds upon the cheapest possible terms; the importance of this will be seen in the fact that the outlay made under this head amounted last year to $3,060,000. In the course of last year the company's works at Penhoet completed the transformation of the steamer *La Fazette*, the old engines and boilers in this vessel being replaced by altogether new and more powerful high-pressure and triple-expansion engines, which have enabled the ship to attain a speed of 14 knots per hour. *La Fazette* was supplied last year with electric lighting apparatus, while her fittings were also materially improved. A similar policy is being pursued this year with the *St. Laurent* and the *Labrador*, so that the company's West Indian line will soon be in a thoroughly efficient state. New boilers are about to be supplied to the company's Mediterranean steamers, which will also be otherwise improved. The efficiency of the Mediterranean fleet will be further increased by two powerful steamers, the *Eugene Pereire* and the *Maréchal Bugeaud*, being placed upon the line. Bronze screws are being supplied to several of the company's steamers which are required to attain high rates of speed. The forced draft has also been introduced into some of the company's ships, but this is being done cautiously, as sundry complex questions have to be considered in connection with it. Not only have the company's works at Penhoet been highly useful in maintaining the efficiency and providing for the renewal and improvement of the company's fleet, but they also did some work last year for the French Admiralty, to which the company recently delivered the *Girafe*, while it is now engaged on a swift cruiser to be named the *Cootlogon*. At the present time the company is employing 1,800 persons at Penhoet.—*London Engineering*.

Natural Gas in China.—Consul Denby writes from Peking to the State Department as follows: "The following abstract of an account given by Baron von Richtofen of natural gas wells in China may be interesting. These wells are found in Sz'chwan, near a town called Tsz-lin-tsing. In an area of 27 li (9 miles) diameter salt wells are found. To make a well the Chinese use a long and elastic bamboo pole, supported in the middle by a cross piece, a rope made by coupling the ends of long (not twisted) slices of bamboo, and an iron instrument which weighs 120 catties (catty=1⅓ lbs.). The rope is fastened on the thin end of the pole, and the iron on the end of the rope. A slight up and down motion of the thick end of the pole makes the iron hop and bore a vertical hoe with its broad, sharpened edge. The ground to be perforated consists chiefly of sandstone and clay. When a portion of the rock is mashed, clear water is poured into the hole, a long bamboo tube with a valve in the bottom is lowered, and the turbid water raised to the top. Pipes of cypress wood are rammed in to protect the sides of the bored hole and to prevent the water contained in the surrounding ground from getting access to the well; the pipes are attached to each other at the ends with nails, hemp, and tung oil. The inner width of the pipes is about 5 in. As the work proceeds the pipes are rammed deeper, and a new one attached on the top; the rope, too, is made longer. At a depth varying from 70 to 100 chang (700 to 1,000 ft.) the brine is struck, and the well is fit for use. The brine is raised to the top through long bamboo tubes and bamboo ropes, as described, by means of a horse-whim, and then carried to large pans for evaporation, or led to them through bamboo pipes.

"Besides these wells there are others, which are bored to the depth of from 1,800 to 2,000 ft. At that distance below the surface petroleum is struck. Immediately on reaching it an inflammatory gas escapes with great violence. Work is now stopped, and a wooden cap fastened over the mouth of the pit, perforated by several rows of round holes. In each of them a bamboo pipe is inserted, and through these the gas is led under the evaporation pans. The pipes ramify, and on each end a tapering mouthpiece, terminating in a small aperture, is attached. The gas is then used for evaporating the brine.

"The enterprising spirit which induced the Chinese to examine the ground at so great a depth is said to have had its origin in the drying up of a brine pit. The proprietor was in hopes of meeting brine at a greater depth, but found instead the gas.

"When the country was infested with rebels during the Taiping rebellion they removed the cap from one of the gas pits and set fire to it. Since that time, or at least up to the time that Baron Richtofen wrote, a long column of fire rose from that pit, and it is considered nearly impossible to stop the flame.

"The gas pits and brine pits are owned separately by corporations. The owners are subjected to the control of the Government. The Government monopoly is in the hands of the 'Taotai,' who resides at the place. The salt works of Tsi-lin-tsing yield considerable revenue to the Government, and have besides enriched numerous proprietors, and given occupation to a numerous population. The number of 'fire pits' is 24, and

the salt pits are innumerable. Some of them do not enjoy the advantages of gas. The brine is evaporated with grass and wood.

"There are salt pits in neighboring localities on the Min River, but no gas pits."

Electric Purification of Sewage.—A patent has recently been granted W. Webster for a system of electric purification of sewage which covers also a similar system of purifying drinking water as well as the waste or sewage water. The Metropolitan Board of Works in London, which is now establishing, at an expense of $5,000,000, a plant for the chemical treatment of sewage, has given Mr. Webster permission to make, at his own expense and under the direction of the officers of the Board, a trial of his invention on a practical scale. The inventor proposes to treat 1,125 cubic meters of sewage per day, running six days a week, and to continue this for a sufficiently long time to establish the merits of his system.

The full particulars of his plan have not been published, but the inventor proposes, instead of placing chemical products in the water to be purified, to form these products from the sewage matter itself by means of an electric current generated by dynamos placed in the work-shops, and by agitating this matter by means of electrodes placed within it.

It seems that the reaction in this case is very curious; instead of being precipitated to the bottom of the purifying tank, as in the case of simple chemical treatment, the impurities mount to the surface, carried up by the gas bubbles originating from the electric current. They can then be skimmed off or can be made to fall back to the bottom by stirring up the tank, the latter operation freeing the solid impurities from the bubbles of gas which were attached to them. It is claimed that this process has the advantages that it is inodorous, that it is continuous, that nothing is added to the weight of the matter to be taken out of the tank, and that it preserves in the impurities a large part of the ammonia, which is very profitable in case these impurities are utilized as manure.

The annual expense of the electric purification of the entire volume of sewage of London is estimated at $125,000. According to the plan of the Board of Works, now in course of execution, the annual expense of the chemical treatment would be $150,000, of which $90,000 would be expended for iron and lime and $60,000 for permanganic acid.

The economy of the electric process would not stop with this first cost, however, because the amount of solid matter to be transported per day would be only 10 tons against 45 tons with the chemical process. These quantities are naturally increased by the proportion of water in which they are found in solution under the form of sediments; the difference is therefore considerable in favor of the electric process.

This chemical plant which the Board of Works is now preparing is not due alone to the progress of ideas on this point, but is really an imperative necessity in order to put a stop to the poisoning of the waters of the Thames. The people on the banks of that river have been for a long time complaining with much reason, and have at last taken legal measures to compel the authorities to put a stop to it.—*M. Berla, in Annales des Ponts et Chaussées.*

Proposed New Patent Court.—Judge Culberson, the chairman of the House Judiciary Committee, has submitted his report in favor of the bill to establish a Court of Patent Appeals. This Court, as provided for by the bill and amendments reported by the Committee, consists of one chief-justice and two associate justices, who shall be appointed by the President, by and with the advice and consent of the Senate, and who shall hold office during good behavior, and receive a salary each of $6,000 per annum.

The Court is required to hold one term annually at the seat of Government, commencing on the second Monday in October, and may hold special or adjourned terms, as the Court may deem proper, for the despatch of business.

Judge Culberson says that among the results reasonably expected to flow from the organization of a Court of Patent Appeals attention may be called to the following:

1. It would enable the public and patentees to determine the value and validity of patents without serious and vexatious delays, and thus promote the interests of all concerned.

2. It will relieve the Supreme Court of much of the burden imposed upon it by this class of litigation.

3. The practice in the Patent Office would become thoroughly fixed and understood, and, as a consequence, the issue of worthless patents, in which unscrupulous persons deal to the injury of the public, would be greatly diminished, if not entirely suppressed.

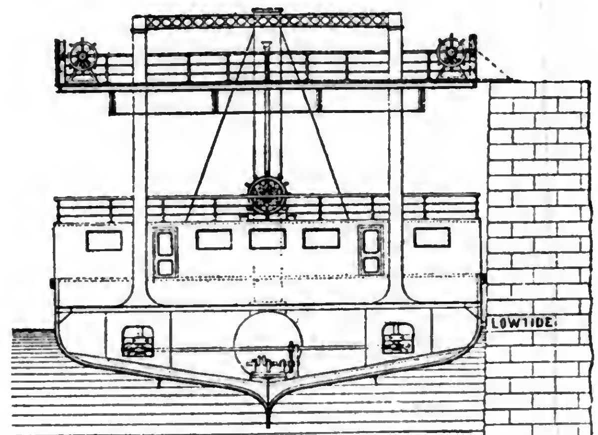
4. It would tend to simplify the patent laws by constriction, and to settle questions of doubt which are often used by litigants for the purpose of injustice and oppression.

Without intending to present the reasons at length which induce the Committee to arrive at the foregoing conclusions, the following observations are submitted: The life of a patent at most is 17 years, and if it is a valuable one or intricate and radical, it usually requires one-fourth of that period to introduce it and secure its use by the public.

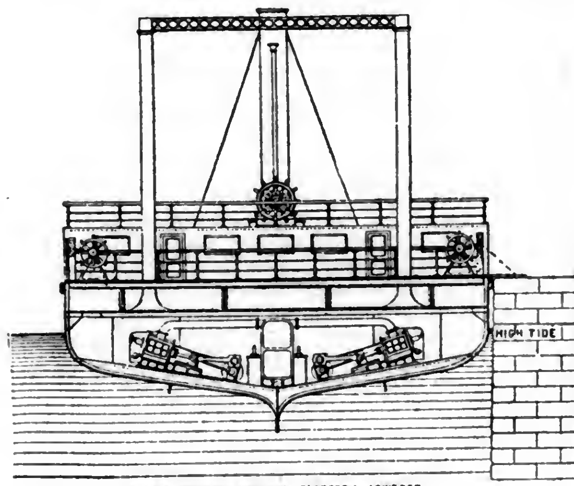
Under the present condition of the business of the courts it requires, ordinarily, from two to three years to obtain a decision in the Circuit Court of the United States, and if appealed to the Supreme Court from three to four years are required to obtain a decision. It may be said that the same difficulty and delay attend the determination of all other questions involving the determination of property rights. While this is true, it should be borne in mind that this species or character of property differs from all other kinds of property. The duration of the owner's title is arbitrarily fixed by law.

The bill provides that the new Court shall make a finding both of facts and of law, and that appeals to the Supreme Court shall be taken on questions of law only, thus very much simplifying the cases and making it possible to secure final decisions in a reasonable time.

An Elevating Ferry Steamer.—The accompanying illustrations, from the London *Engineer*, show a peculiar steam ferry-boat, designed for the River Clyde at Glasgow by W. Simons & Company, ship-builders, at Renfrew, Scotland. In this case, instead of providing movable landing stages to meet the rise and fall of the tide, the deck of the ferry-boat itself is a movable platform carried on six hydraulic elevators, by which it can be raised or depressed as required. The boat itself is a double-ender 150 ft. long, 55 ft. extreme breadth, 17 ft. 6 in. depth of



CROSS SECTION SHEWING PLATFORM ELEVATED.



CROSS SECTION SHEWING PLATFORM LOWERED.

hull, and having a draft of water of 12 ft. 6 in. It is driven by twin screws, propelled by two sets of triple-expansion engines of the ordinary type. Each end of the boat is provided with twin screws and a rudder, and the engines can be coupled to either end as desired. On each end of the main deck a cabin is provided, and the entire space between these cabins is filled up by the movable deck, which has a rise of 25 ft. altogether. The landing is made at the side. The illustrations show cross-sections of the boat with the deck lowered for high tide and raised for low tide. A slight modification of the present design would adapt the boat equally well for an end landing, and, in fact, the plan permits of almost any change to suit local circumstances.

THE RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

PUBLISHED MONTHLY AT No. 45 BROADWAY, NEW YORK.

M. N. FORNEY, ... Editor and Proprietor.
FREDERICK HOBART. . . . . Associate Editor.

Entered at the Post Office at New York City as Second-Class Mail Matter.

SUBSCRIPTION RATES.

Subscription, per annum, Postage prepaid	$3 00
Subscription, per annum, Foreign Countries	3 50
Single copies	25

Remittances should be made by Express Money-Order, Draft, P. O. Money-Order or Registered Letter.

MR. J. HOWARD BARNARD, 7 Montgomery Avenue, San Francisco, Cal., is the authorized Western Agent for the JOURNAL.

MR. FREDERIC ALGAR, Nos. 11 and 12 Clements Lane, Lombard Street, London, E. C., England, is the authorized European Agent for the JOURNAL.

NEW YORK, NOVEMBER, 1888.

THE new cruiser *Baltimore*, which was launched from the Cramp Yard on the Delaware, October 6, is the largest of the new ships for the Navy yet afloat. The *Baltimore* is intended as a fast cruiser and is not a heavily armored vessel, being furnished only with a protective deck, which covers the machinery of the main part of the vessel, while the engine, magazine, etc., are further protected by the arrangement of the coal-bunkers. The new ship is 335 ft. long over all, 48½ ft. beam, with a mean draft of 19½ ft., and her total displacement will be 4,400 tons. She has two triple-expansion engines, with cylinders 46, 60 and 94 in. diameter and 42 in. stroke, driving twin screws. These engines are expected to develop 7,500 H. P., and by contract she is to make at least 19 knots an hour, with the boilers running under forced draft. At a lower speed she will have a wide cruising range and, with the heavy armament she will carry, will be the most formidable vessel belonging to our Navy until the *Maine* and the *Texas* are completed.

THE most recent addition to the Navy, and the smallest of the new vessels, is the gun-boat *Petrel*, which was launched from the yard of the Columbian Iron Works at Baltimore, October 13. The *Petrel* is only 175 ft. long, 31 ft. beam, and 12 ft. mean depth, with a displacement of 855 tons, but she will carry a heavy armament for a vessel of her size. This will consist of four 6-in. rifled cannon, two revolving guns, two rapid-fire machine guns, and one Gatling gun, making quite a formidable battery. She is not expected to be a very fast boat, the contract speed being 13 knots an hour. The machinery is a triple-expansion engine, capable of working up to 1,350 indicated H. P. For many purposes she is expected to be a very useful boat, but no other of the new vessels is as small, with the exception of the practice vessel for the Naval Academy, authorized by this year's appropriation bill. This will be about the same size, but the plans for it have not yet been prepared.

THE New York Railroad Commission has recently given three hearings to representatives of the railroad companies of the State, in relation to the adoption of a uniform coupling for cars heated by steam. The law prohibiting the use of stoves takes effect this winter, and most of the New York companies are now putting some system of steam heating in their cars, so that the question of couplings is one needing attention, especially by those companies which interchange passenger cars.

The hearings did not result in anything further than to show that there is a considerable difference of opinion as to couplings, and that each company represented is disposed to adhere to the particular system which it has adopted. No progress was made toward uniformity in this respect, and it seems as if it would be a hard matter to secure it. As the different steam-heating systems find their way into use this difficulty is sure to increase. Passenger equipment, it is true, is not interchanged to any great extent, except in the case of sleeping cars, but the difficulties arising from the use of various couplings will still be a source of serious annoyance, and it is to be regretted if nothing can be done toward securing some agreement in this matter.

THE article on Japanese railroads, which is published on another page, is an interesting account of the railroad activity now prevailing in that country, whose people, as is well known, have shown a disposition—strongly in contrast with that of most other Oriental nations—to adopt the mechanical and other appliances of Europe, the railroad apparently being especially attractive to them. At the first glance the peculiar shape of the islands of which the Empire is composed makes it appear an easy matter to plan a complete system, but the fact that the interior of those islands is generally rough and mountainous, a lofty chain of hills running through almost their whole length, interposes many difficulties. Nevertheless the whole of the main island of Nippon can be made readily accessible to the capital and the chief seaports by means of two lines—one on each side of the mountains and parallel to the coast—with branches where needed, and this seems to be very much the system which is being followed. The first lines in Japan were built by the Government, but those now under construction are about equally divided between the Government and the private corporations, the organization of companies having been authorized by the State under fairly liberal conditions, although all the railroads will be under strict Government supervision.

IT is to be noted that not only are railroads making more rapid progress in Japan than in any other Asiatic country, but also that it is the only eastern country which is building its own roads. With the exception of some service as consulting engineers, very little is now being done there by foreigners, while the private companies, which are entering extensively into the work, have been organized by Japanese enterprise, and their money is supplied by native capital. The lines so far constructed have been very profitable, and as the Government has taken steps to prevent the undue multiplication of railroads, it is very likely that they will continue to yield excellent returns. At present railroads are the favorite form of investment, and the

organization of the new companies has brought out a very large amount of money which has heretofore been hoarded up and inactive, and in this way the country will be largely benefited.

The Japanese intend not only to build railroads with their own money, but they also mean that they shall be built by their own engineers, and they have taken pains to train men for that purpose. Many Japanese students have been educated in Europe and America, and the Imperial University at Tokyo has now a very complete engineering school, with foreign and native professors of high standing. It will not be long before the country will be in this respect almost entirely independent of foreign assistance. There must be, however, for some time, a large importation of foreign material ; but as workshops of every description have been established and are continually being extended, these importations will include more and more only the raw material, and less and less manufactured and finished products.

Too little attention has been paid by engineers to the study of watercourses, and on a new road the consequences are always troublesome and frequently disastrous. The larger rivers are watched carefully enough and their rise and fall noted ; but the smaller streams are apt to be neglected in building a road, and the necessary waterways at their crossings are merely guessed at, and a bridge or culvert put in according to the idea which the locating engineer may form when he sees them. It is not meant by this that there are no exceptions to the rule ; locating engineers are found here and there who will take proper care to provide sufficient waterways, but the looser practice is the too general rule, and the results are found in frequent washouts, until the necessities of the operation of the road compel an improvement.

Instances of this could be multiplied, but one which will serve at present can be found near by New York, where a road built some years ago had on a section of 12 miles some 15 water-crossings, every one of which had to be enlarged within two years after it was built, while several were twice altered. Now this road was through an old, settled country, where people could be found who had been familiar for many years with the behavior of the streams, and where a little inquiry and study of the water-marks would have shown what might be expected. Little or no pains were taken, however, and the result was, besides the cost of putting in new bridges, the loss of many thousand dollars from interruptions to traffic, and at least one bad accident from a washout.

In entirely new country data would be harder to obtain than in this particular instance ; but much might be learned from careful observation and study of the country. These would take some time, of course, but it would be time well spent and prove economical in the end.

In this connection the notes of a Japanese contributor, which will be found on another page, will be of interest as showing with what care the question is studied there, and the way in which it is taken up and treated.

THE comments of French engineers on American municipal engineering, which will be found on another page, are of interest as showing how our varied systems—occasionally lack of system—in such work strike a foreign observer. Their criticisms appear to be just in some respects, but in others rather severe ; but the effect of the latter is somewhat modified by the very handsome compliment to American engineers with which the report concludes.

THE East Tennessee, Virginia & Georgia Railroad will not pass under the control of the Norfolk & Western Company, as expected, the negotiations for its transfer having failed. The road is to be leased to the Richmond & Danville Company, and will continue to be worked under the same conditions as for some time past.

THE ENGLISH VERSUS THE AMERICAN SYSTEM OF RAILROAD CONSTRUCTION.

A CORRESPONDENT has sent us a copy of the *Japan Weekly Mail*—a paper published in the English language in Japan—which contains two articles, one a translation from the *Jiji Shimpô*—another Japanese paper—in which the writer advocates the use of the American system of railroad construction for the railroads of Japan. The article in the *Mail* is a reply to this, and the two form an entertaining, although not very instructive, discussion of this much-disputed subject written by a Japanese and by an English resident of that country. The articles are too long for reproduction in these pages, so that in reviewing them our readers must be content with a brief condensation of the arguments on both sides, which seem worthy of consideration. It may be added that it is not the purpose of this article to give support to either of the disputants, but rather to point out wherein their premises are wrong or their reasoning fallacious, or lacking in comprehensiveness.

The writer in the *Jiji Shimpô* says of American locomotives that " they cost less to construct, burn less coal, are said to be constructed on more advanced principles, are better adapted for steep ascents and descents, and can be more easily stopped than English engines."

To this the *Mail* answers that " it was demonstrated a short time ago in the public press that American locomotives are constructed of inferior material, are about one-third more expensive, are less serviceable, and consume more fuel than English."

This in substance is all that is said of this important branch of the subject by our antipodal disputants, and all who are concerned for the reputation of either American or English locomotives must feel that neither side has made a very strong case.

Quite curiously, while we coincide with the opinions of our *Jiji Shimpô* friend regarding the relative merits of English and American locomotives, yet it would be impossible to agree unreservedly with any one of his reasons for preferring Yankee locomotives to those of British manufacture and design.

With reference to " cost," it is not quite clear whether the price at which locomotives can be bought in the two countries, or the cost of manufacture of engines of the different designs is what the writer means. At present locomotives of the American standard type can be bought for about eight cents per pound, counting the weight of the engine and tender *light*—that is, without water or fuel in either ; and made by our best builders. We have no data at hand concerning the present price of locomotives in England, but wrought-iron wheels, plate frames, crank-axles, brass tubes, and copper fire-boxes, which are gen-

erally used on English locomotives cost more, under like conditions, than cast-iron wheels, bar-frames, axles without cranks, iron tubes, and steel fire-boxes. But it will be said that English builders will, if required, make locomotives with the parts named constructed as they are in America. To this it may be said that English cast-iron is not as well suited for making wheels as our best American wheel irons are, that the manufacture of bar-frames requires special and expensive tools and machinery to make them to the best advantage. Of course English builders can and do make locomotives with iron tubes, steel fire-boxes, outside cylinders, and without crank-axles, but that is not their general practice. Locomotive building is like a religion in that, to a considerable extent, it is an accumulation of traditions and a consequence of the needs and experience of those who have practiced it for years past. The American and the English systems have both accumulated a great mass of such experience during the years in which they have been developed. The one cannot be transplanted from the land of its birth and growth to a foreign soil without more or less difficulty, and it would probably be as hard for an English builder to make an American locomotive as it would be to have an English engine constructed in an American shop.

Any one who asserts that the workmanship on English locomotives is not as good as the work done in this country simply makes an exhibition of his ignorance of the magnificent equipment in tools and machinery of the locomotive shops of that country, and of the skill of their workmen. The superiority of American railroad practice consists in its adaptation to the needs of a new country with limited capital. Our railroads were all "hard up" for money when they were built. The repair shops were always poorly equipped with tools, and the appliances for making repairs were insufficient. As a consequence locomotives were designed so as to make their repair easy and cheap. Furthermore, most of our master-mechanics or locomotive superintendents have risen from the ranks, and many of them have been locomotive runners. Therefore, in having their engines built, they gave a great deal of consideration to the convenience and comfort of the men who run them ; more, it is believed, than has been given in England.

Furthermore, our locomotives have had to run over lines with no other ballast than that which mother earth supplied on that part of her bosom where the road was built. The lines were crooked, the rails often worn, and the track rough. The locomotives had to run on such lines or not run at all. As there was no money to reconstruct the roads or put them in proper condition, the rolling stock had to be adapted to run on rough roads. This, as has often been pointed out, is done by adopting the truck, or "bogie" system, as our brethren in England call it, and also by using systems of equalizing levers between adjoining axles so that the weight is transferred from one to the other.

It is, of course, true that English builders can and do make locomotives with outside cylinders ; they use a truck and equalizing levers in many cases, and there is hardly any one thing which is used on American locomotives whose counterpart may not be found on English locomotives. But, as has been pointed out before, there is an unwritten and unwriteable system which experience and tradition has established, and which cannot be carried bodily or transplanted at will from one side of the Atlantic to the other. Matters of proportion which appear trivial, in practice become of the utmost importance, and make the difference between keeping the engine in service or being obliged to lay it up for repairs. Questions of theory, too, under the light of experience often assume quite a different aspect from that which they have without such illumination. Take, as an example, the use of rocker-shafts for valve-gear. An English locomotive designer would generally be willing to submit to mild torture rather than to use rocker-shafts in connection with the valve-gear of locomotives, because to him it appears to be a quite unnecessary and useless complication. Now, while theoretically this position is, in a certain sense, quite sound, on the other hand, the introduction of a rocker-shaft allows the valves, valve-faces, and steam-chests to be placed on the outside of the frames and on top of the cylinders, where they are easily accessible in making repairs. As an answer to the theoretical objection to using what seem to be unessential parts, it may be said that experience has shown that if the rocker-shafts are constructed in accordance with American practice—that is, with a bearing extending the whole length of the shaft—that there is hardly any working part of a locomotive which costs so little to maintain. Its first cost is not very great, and it allows of free access to the valves and steam-chests.

With reference to fuel consumption no one seems to be in a position to be able to speak confidently of the relative economy of English and American locomotives. There can be no doubt of the fact that, under the conditions that they work, some English locomotives are working very economically. Broad deductions from great masses of facts are apt to be misleading, and when the plan is adopted of collecting all the attainable facts and guessing at those which are unknown, almost any position can be proved. In the absence of any data which are comparable, it may be said that there is no reason apparent why an English locomotive boiler, as constructed in that country, should be more or less economical than American boilers as they are made here. The same is true of the use of steam in the cylinders and valve-gear. The fact is, though, that more attention has been given in this country to increasing the capacity of locomotives for doing work than to economizing fuel ; for the reason that there has been more pressing need for it on account of a very common scarcity of motive power. It may be safely asserted that American locomotives are generally worked harder, and do more work in proportion to their weight than English locomotives do. This is due to the fact that the conditions of traffic on English lines do not require the engines to pull as heavy loads as locomotives here must, because here there is often a great deal of lading and little motive power ; and also because it has been learned here that the wages of the trainmen—that is, the locomotive runner, fireman, conductor, and brakemen—amount to more than the cost of fuel, so that to pull a given percentage, say 10 per cent., more load will result in a greater economy than saving the same percentage of the fuel. In other words, the pulling capacity of locomotives is—from an economical point of view—more important than their consumption of fuel is. It of course would be desirable to haul big loads, and to burn as little fuel as possible in doing it. With maximum loads we know of no reliable data from which the performance of English and American locomotives can be compared. American locomotive engineers have no reason to fear such a comparison, how-

ever. The need of pulling very heavy loads here has led to the use of large grates and fire-boxes. This practice has become much more general of late years than it was theretofore, and it seems probable that, in a contest in heavy pulling, our locomotives with large grates and fire-boxes would come out ahead, both in capacity and economy.

Much interest is felt in the arrival of the Webb compound engine, which the Pennsylvania Railroad has ordered, when a comparison of the performance of an English with American locomotives under like conditions will be possible.

One very significant fact, though, which is strong evidence in favor of the American system, is that it has been adopted on the Grand Trunk Railroad of Canada after that road was built by English engineers, and was first equipped with English rolling stock, and all or nearly all its officers were Englishmen. If there is an instance where any of them has not been a convert to the American system after a few years' experience on that line, we have not heard of it.

The Canadian Pacific, built with British capital and the longest single line in the world, has followed in the footsteps of the Grand Trunk and adopted the American system.

So much space has been taken in discussing locomotives that there is no room to devote to cars and other appliances, which will be taken up in the December JOURNAL.

THE PARIS EXPOSITION OF 1889.

THE proper representation of the United States at the Paris Universal Exposition of 1889 is a matter which has not excited the interest in some directions which might be expected. The United States Commission and their assistants have been working very energetically, but have not met with as much support and assistance from manufacturers as they should have received. The time for preparation, under the rules adopted for the Exposition, is now limited, as the final allotment of space will take place November 15, and the shipments by steamer must begin in January next. The Exposition itself will open May 5, 1889, and close October 31, the time for receiving exhibits being from January 1 to March 31, 1889. Under the rules of the Exposition there is no charge for space occupied by exhibitors, and under the law creating the United States Commission exhibits will be forwarded free of freight between New York and Paris, and will also be returned in the same way.

We are informed that while in some departments of manufacture there will be a very creditable exhibit, so far comparatively little has been offered which will illustrate the railroad machinery of the United States. Great interest is felt abroad in American railroads, and for many reasons it would be very desirable to have a full exhibit of our locomotives, cars, and railroad appliances, and it is to be hoped that manufacturers will come forward within the remaining time and make up the deficit in exhibits. In some other departments of machinery there is also abundant room for additional entries still to be made.

It will be of interest to give some particulars in relation to the Exposition generally. The buildings to be used are now nearly completed, and are very extensive, the total area covered by them and by the enclosed grounds being about 3,000,000 square feet. The principal buildings are three in number, called the Palace of Liberal Arts, the Palace of Fine Arts, and the Main Building, in which last the machinery exhibits will be placed. From the information already received, it is expected that the total number of exhibitors from all countries will reach 30,000, and that the exhibits will come from all European countries, except Germany, from South America, and from Mexico, from Japan a very large exhibit will be sent, and from other Oriental countries there are many entries.

The exhibition will be divided into nine groups: 1. Works of Art; 2. Education and Processes Used Therein; 3. Plain and Decorated House Furniture; 4. Textile Fabrics; 5. Raw and Manufactured Products of Mining, Forestry, Chemistry, etc.; 6. Apparatus and Methods of Mechanical Industry; 7. Food Products; 8. Agriculture, Vine-Culture, and Fish Culture; 9. Horticulture. These nine groups are again subdivided into 83 classes. The classes which will especially interest our readers fall under the Sixth Group, and include: Class 59. Machines for various purposes; Class 61. Railroad Appliances, including permanent way, motive power, and rolling stock; Class 62. Electricity and Electrical machinery; Class 63. Appliances and methods of Civil Engineering, Public Works, and Architecture; Class 65. Navigation and Life-saving, and Class 66. Apparatus and methods of the Art of War.

The usual awards of medals and diplomas will be made, although the details of these have not yet been determined. In the last French Exposition, in 1878, the exhibitors from the United States carried off much more than their comparative share of awards, and it is hoped that the same standard will be maintained next year.

The commercial advantages to be derived from a full representation will undoubtedly be considerable, and have been so often mentioned that it is hardly necessary to repeat them.

There is no doubt that, as has been proved before, many of our mechanical appliances need only to be brought to the notice of other nations to secure their adoption, and there will be no such opportunity offered for several years as that now presented at Paris.

The American exhibit, and the interests of those who may take part in it, are in charge of General William B. Franklin as Commissioner-General and of Assistant Commissioner-General Somerville P. Tuck, who have established their offices at 35 Wall Street, New York. All business in relation to the Exposition must be done through these gentlemen, as the French Commission does not correspond with foreign exhibitors, dealing with them only through the authorized representatives of the respective nations.

The law under which the Commission has been appointed appropriated the sum of $250,000, which will be used in defraying the necessary expenses. It may be added that the exhibits, in case the exhibitors are unable to go to Paris or to send representatives, will be cared for free of expense, except that of unpacking and repacking. No duties will be charged by the French Government, except on such goods as may be sold during the Exposition to remain in that country or be consumed there. The French regulations also state that the objects exhibited will have full legal protection aginst piracy of inventions or designs, so that no hesitation need be felt about exhibiting patented machines or appliances.

There is still time to arrange a good railroad exhibit if manufacturers will take the necessary interest, and will do each his share toward it, and national pride, if not self-interest, might well prompt such action.

THE NICARAGUA CANAL.

THE present year will be marked in the annals of American engineering by the actual beginning of work on the Nicaragua Canal between the Atlantic and Pacific oceans. This will be so great and important a work, considered either in its commercial relations or as an engineering work simply, that it must be considered fortunate that it has been planned and will be carried out under the direction of American engineers.

The project is also of interest to those branches of art and industry which will be called into use in its construction, so that its influence will be felt far beyond the commercial and financial circles where its most immediate interest seems, at the first glance, to be centered.

The work accomplished by the promoters of the Nicaragua Canal during the current year, and the manner in which it has been done, give assurance of safe and steady progress in the future stages of the undertaking. With all details covered by minute and careful preparation, the surveying expedition sent out at the end of 1887 fulfilled its task so satisfactorily that it may be fairly said that every problem connected with the construction of the canal is definitely solved, every element of doubt removed, and the path hewn in which the constructors are to follow the footsteps of the pioneers. Meantime the management has pursued the work of preparation and organization in other directions, overcoming obstacles and perfecting plans, so that all is ready for the commencement of active operations in Nicaragua as soon as the charter is obtained for the corporation of execution contemplated by the canal concession—the "Maritime Canal Company of Nicaragua."

The groundwork of the enterprise, the concession from Nicaragua, has been supplemented by a similar grant from Costa Rica, whose territory, by virtue of a recent decision in a boundary arbitration, will touch the canal line in the valley of the San Juan River. These two contracts secure to the Maritime Canal Company an exclusive title to and control over the canal route for a term of 99 years, with a renewal clause. They also invest the grantees with valuable tracts of land, amounting altogether to more than a million of acres, and with all the necessary privileges of pre-emption, free use of materials, immunity from taxes and duties, guarantees of government aid and support, which can facilitate the execution of the work and assure its value when completed.

The charter which is sought for the ultimate company is an Act of Congress, clothing the incorporators with the necessary powers to carry forward the undertaking, but without any financial support or guarantee whatever. Such an act was passed by the United States Senate in February last, but was not reached in the House of Representatives before the close of the present session of Congress. The project will not be allowed on that account to flag or halt, but the necessary corporate powers will be obtained under State laws or from a State Legislature, the legal effect and authority of which would be precisely the same as those of a Congressional charter.

The route of the Canal is from San Juan del Norte, or Grey Town, on the Caribbean Sea, to Brito, on the Pacific, a distance of 169.8 miles ; but of this distance only 28.9 miles is canal in excavation, or a little more than one-sixth of the total length of the line. The remainder is free navigation in Lake Nicaragua, the San Juan River, and the basins of the rivers Deseado, San Francisco and Tola. The lake, which is the great natural feature of this route, is a body of water 2,600 square miles in area, with a drainage area of 8,000 square miles, and a mean daily flow, through its outlet, the San Juan River, of 1,272,153,600 cubic feet, or many times the requirements of the artificial works it is destined to feed. The navigation in the lake is 56.50 miles, and in the San Juan River, 64.54 miles. The summit-level, 110 ft. above the sea, will be maintained for 150 miles, beginning at the eastern divide, some 16 miles west of Grey Town, and continuing to the west side of the Tola Basin, less than four miles from the Pacific Ocean. One double lock and one single one on the west end, and three single locks on the east end, will drop the canal to the level of the sea. The width in excavation will be from 80 to 120 ft. at bottom, and from 174 to 288 ft. at the surface ; the depth, 30 ft.; but that part of the line in the lake, river and basins will have, throughout nearly the entire length, a width and depth which will render navigation almost as convenient as on the high seas.

A railroad and telegraph line will be built along the entire canal on both sides of the lake, and it will be lighted by electricity. It is also proposed to utilize the water power to the utmost practicable extent, by hydraulic and electric appliances in both construction and operation. The harbors are to be improved by means of piers and breakwaters, and the eastern and western extremities of the canal will be widened to afford convenient access, safe anchorage and dockage. The locks, 650 ft. long and 70 ft. wide within the chambers, will be built with concrete and masonry. The principal engineering features, besides the improvement of the harbors and the construction of the locks, are the rock cut through the eastern divide, and the various dams and embankments. The rock cut is three miles long, at an average height of 149 ft. above the bottom of the canal through that distance. The cost of this cutting is estimated at nearly $12,000,000. By the dam at Ochoa, 52 ft. above the surface of the water, and 1,255 ft. on the crest, the upper 64½ miles of the San Juan River will be converted into an extension of the lake. The dam at the western extremity of the Tola Basin, near the Pacific, will be 71 ft. high and 2,100 ft. on the crest. For impounding the waters to form the San Francisco Basin, in the Eastern Division, five dams will be required, varying from 1,200 to 1,700 ft. in length, but of inconsiderable height, and there will be some secondary embankment along the crest of the impounding ridge, varying in height from 5 to 30 ft. These dams and embankments are substituted for a single dam of 6,000 ft., intercepting the Rio San Francisco near its junction with the San Juan, and proposed in the plan of 1885. There will be a dam of smaller dimensions, and a waste-weir at the east end of the Deseado Basin.

The time limited in the concession for the completion of the canal is 10 years, but it is believed that six will suffice. Fifty million dollars will probably be spent upon the work.

The experience of the surveying expedition which went to Nicaragua in November last, and the members of which have just returned here, is a sufficient guarantee that no unfavorable climatic conditions will interfere with the operations or jeopardize the safety of those who engage in them. Nearly 200 men were in the field for seven months, and not one was lost, and there was not a case of serious illness among them. It has also been demon-

strated that Nicaragua and the neighboring States can furnish plenty of good material for the supply of manual labor needed on the work, and the fresh provisions needed for the sustenance of the working force. An abundance of excellent timber, and all the necessary stone, clay, sand and lime for construction work, are to be found on the line of the canal.

The estimate which has been made in the interest of the company, and which is based on the statistics of the United States Treasury Department and of foreign countries, is that, if the canal were now open, the traffic seeking this route would be about 4,500,000 tons. By the time it is completed—say in 1894—the development of the North-west Pacific Coast will probably increase this to 6,000,000 tons. With a toll-rate of $2.50 per ton, this would yield sufficient income to pay interest on a capital of $200,-000,000.

The great distance saved by the canal—about 10,000 miles—in the voyage between Atlantic ports in the United States and those of the Pacific Coast is well known to all who have considered the subject at all. It is altogether probable that this shortening of the route will give a great impulse to the ocean traffic, and will enable steamships to compete for business which now goes by rail. The advantage given to American merchants in their competition for the trade of the west coast of South America will also be very considerable. The results expected from the canal, however, have been so often set forth, that it is hardly necessary to speak further of them here.

THE QUAKER BRIDGE DAM.

WHEN the new aqueduct intended to bring an additional supply of water to the City of New York was undertaken, it was evident that, while the total yearly supply from the Croton River would be sufficient for the needs of the city for a long time to come, it would fail to meet the demands upon it in the dry season, unless large additional storage capacity were provided. A great storage reservoir was therefore planned, which was to be formed in the Croton Valley by the building of what is known as the Quaker Bridge Dam, which will, when completed, be one of the famous masonry dams of the world, and one of the largest—if not the largest—structures of the kind in existence.

The new dam will close a ravine varying in width from 1,300 ft. at the level of the top of the dam to 300 ft. at the river bed ; it will be 270 ft. high from foundation to parapet, and will form an artificial lake 16 miles long, 165 ft. deep at its lower end, and holding about 5,000,000,000 cubic feet of water. It will be nearly 100 ft. higher than any masonry dam yet built.

So great an engineering work naturally excites much attention, and since its construction has been virtually decided on there has been much discussion over its exact location, plan, and details of construction. The location chosen was pointed out by nature, but there was, of course, some opportunity for variation within certain limits. A rock foundation is found at the chosen point, not very far below the surface.

The various plans which had been prepared and presented for the dam were some time ago submitted to a commission of experts—Messrs. Joseph P. Davis, J. J. R. Croes, and William F. Shunk—and they have just submitted an elaborate report to the Aqueduct Commission. This report discusses in detail all the conditions likely to affect the stability of the structure, the forces which it must resist, and the best form and methods of construction to be adopted.

Examining carefully all the circumstances of the case, the experts do not wholly approve of any of the plans submitted, either for exact location or for the section of the dam, and they have therefore prepared plans of their own which are offered for the approval of the Commission. They recommend the building of a dam curved on a radius of 1,146 ft., on the grounds that the structure will be more pleasing in appearance, and also better able to resist extraordinary forces, if built on a curved line. They have prepared a carefully studied cross-section, varying in thickness from 235.5 ft. at the foundation and 133.2 ft. at the level of the river-bed to 27 ft. at the water level and 20 ft. at the parapet, the water side being carried down with a moderate batter and face on a curve. The total area of this cross-section is 27,481 square feet, and the dam, if built on this plan, will contain about 555,000 cubic yards of masonry—a statement which will give some idea of the magnitude of the work.

Some criticisms have been made upon the delay in adopting plans for this work ; but it is well to consider that a structure, the largest of its kind in the world, which is to cost nearly $5,000,000, and is to be of vital importance to the future well-being of a great city like New York, cannot and ought not to be hastily planned. The time given to careful consideration and comparison of plans is well spent, especially when this work is in competent hands.

The report is an admirable document of its kind, and it is to be hoped that its recommendations will meet with favor. The Quaker Bridge Dam ought to be, as a successful engineering work, an honor to the city which is to build it and an enduring monument to its designers and constructors.

NEW PUBLICATIONS.

ALFRED KRUPP : A SKETCH OF HIS LIFE AND WORK : AFTER THE GERMAN OF VICTOR NIEMEYER, BY K. W. AND O. E. MICHAELIS. TO WHICH IS ADDED A VISIT TO THE KRUPP WORKS AT ESSEN : FROM THE FRENCH OF CAPTAIN E. MONTHAYE, TRANSLATED BY CAPTAIN O. E. MICHAELIS, U.S.A. New York ; Thomas Prosser & Son, No. 15 Gold Street.

The life of a man who, like Alfred Krupp, practically created the largest steel manufacturing establishment in the world, necessarily has the interest which attaches to that of any man who is placed by his genius and attainments above his fellows in any branch of life. That Herr Krupp had genius there is no doubt, for no ordinary man could have overcome the difficulties and the opposition which he encountered or could, in a single lifetime, have developed the obscure little factory which his father left him in 1826 into the immense works which existed under his sole control at the time of his own death 61 years later.

The sketch of his life which is given in the present volume is short and is not burdened with unimportant details, but is long enough to give the reader a good idea of the strong individuality of the man. Necessarily it has much

to say about the Krupp Works, for it may fairly be said that Herr Krupp and his factory were one, so much was his personal influence and oversight felt in every part of the establishment, and so completely was he absorbed in it. It could hardly be otherwise, in fact, for so great an enterprise could not be built up without ceaseless labor; and while assistants enough could be found, the directing impulse must and did come from the head.

The second part of the book gives an account of the Essen Works in their present state, and gives the reader some idea of their great extent and the variety of work done there.

ABOUT BOOKS AND PERIODICALS.

In its October number the National Car and Locomotive Builder publishes the first of a series of articles on Railroad Car Construction, by Mr. William Voss, Assistant Master Mechanic of the Burlington, Cedar Rapids & Northern Railroad. The Author is a practical car-builder of long and varied experience, and is also possessed of technical and theoretical knowledge. The opening number promises well, and if the remaining ones come up to the same standard, they will form a valuable treatise, which is much needed. There is no practical work—indeed no book of any kind—in existence on this subject, and there is no doubt that the publication of a good one will be fully appreciated by those for whom it is intended.

An article appeared in Harper's Weekly for September 29, by G. T. Ferris, describing the torpedo system at Willet's Point. The article is fully illustrated and of much interest to those interested in this subject. The same paper, in its number for October 20, has an illustrated article on the American Coast and Geodetic Survey.

The Magazine of American History for October shows, in an interesting way, the contrast between the old and the present methods of travel, in a Diary of a Trip from New York to Niagara in 1828, kept by the late Colonel William L. Stone, well known to old New Yorkers. The trip was made from New York to Albany on steamboat, from Albany to Niagara alternately by stage, canal packet and private carriage.

An illustrated article on American Machine Cannon and Dynamite Guns appeared in the Century Magazine for October. A full description of the Gatling, Gardner and Maxim machine cannon and the dynamite guns of Captain Zalinski is given.

The railroad article in Scribner's Monthly for November is on The Every-Day Life of Railroad Men, by B. B. Adams, Jr. Mr. Adams' experience as a station agent on a New England railroad for many years, and the acquaintance with trainmen's ways and habits necessarily acquired in that position, have enabled him to write from an inside standpoint, and to give an account of the hardships and pleasure of that life.

BOOKS RECEIVED.

Third Biennial Report of the Bureau of Labor and Industrial Statistics of Wisconsin: Frank A. Flower, Commissioner. Madison, Wis.; State Printers.

Annual Report of the Board of Regents of the Smithsonian Institution: Part I. Washington; Government Printing Office.

The Fisheries and Fishery Industries of the United States: Section I, Natural History of Useful Aquatic Animals. Washington; Government Printing Office. This volume has been prepared through the co-operation of the Commissioner of Fisheries and the Superintendent of the Tenth Census by Professor George Brown Goode, Assistant Director of the United States National Museum, and a staff of associates. It is accompanied by an atlas of 277 plates. It includes a number of useful and interesting monographs on the food-fishes of the United States and the neighboring waters.

American Journal of Mathematics, Volume XI. No. 1: Simon Newcomb, Editor; Thomas Craig, Associate Editor. Baltimore; published under the auspices of the Johns Hopkins University. The present number contains articles by Captain P. A. MacMahon, R.A., on a New Theory of Symmetric Functions; by William Woolsey Johnson on the Integrals in Series of Binomial Differential Equations; by M. Maurice d'Ocagne on Certain Curves which can be Joined to Plane Curves for the Study of their Infinitesimal Properties; and by Professor Cayley on Surfaces with Plane or Spherical Curves of Curvature.

Revista De Obras Publicas E Minas: Proceedings of the Portuguese Association of Civil Engineers. Lisbon, Portugal; issued by the Association.

Thirteenth Annual Report of the Railroad Commissioners of the State of Missouri, for the Year ending December 31, 1887: James Harding, William G. Downing, J. B. Breathitt, Commissioners. Jefferson City, Mo.; Tribune Printing Company, State Printers.

Occasional Papers of the Institution of Civil Engineers. London, England; published by the Institution. The present installment of these papers includes Transmission of Power by Compressed Air, by Professor William Cawthorne Unwin; Effect of Rolling and of Wire-drawing upon Mild Steel, by Horace Allen; Balancing Foreign Currents on Telegraph Circuits, by John William Fletcher; Varieties of Clay and their Distinguishing Qualities for Making Good Puddle, by William Gallon; Pumping Machinery in the Fenland and by Trentside, by Lawrence Gibbs; Sewage Flow of Chiswick, by Joseph Hetherington; Railway Engineering in British North America, by Robert Jarratt Money; Abstract of Papers in Foreign Transactions and Periodicals.

Royale Universita, Romana, Scuola d'Applicazione per gl' Ingegneri: Annuario per l'Anno Scolastico, 1888–89. Rome, Italy; issued by the University.

The Ashton Valve Company: Catalogue of Safety-Valves. Boston, Mass.; 1888.

Illustrated Catalogue of Wood-Working Machinery: Witherby, Rugg & Richardson. Worcester, Mass.; 1888.

The Keystone Seal and Press: Catalogue and Description. New York; issued by the Keystone Seal & Press Company, No. 170 Broadway.

THE PRINCIPLES OF RAILROAD LOCATION.

By Professor C. D. Jameson.

(*Continued from page* 445.)

CHAPTER XXXIV.

EARLY RAILROAD LOCATION.

The use of the inclined plane and stationary engine far antedate the modern railroad; but in these first examples the inclines were obliged to be straight, and consequently of no great length. In surmounting any great elevation a number of separate inclines had to be used, with short pieces of comparatively level track connecting them. This necessitated a number of separate engines and much more expensive construction.

Among the earlier railroads in this country (particularly in the mountainous region along the Atlantic coast) many were first located so as to include in their future construction inclined planes to be worked by stationary engines; these inclined planes to be operated in connection with the ordinary railroad, and in some cases with canals.

Very few of these inclined planes, however, were built, at least upon any of the roads that to-day are of any importance. This was due to the fact that when railroads were first located in this country, the only precedents the engineers had to guide them in their work were English examples.

In the early development of the locomotive, there was much doubt as to the possibility of a locomotive with smooth drivers upon a smooth rail having sufficient tractive power to pull a load of sufficient weight to pay for the expense of running the engine, and consequently many of the first experimental locomotives were built with toothed drivers to run on a rack-rail, thus doing away with all possibility of great speed and consuming much of the power in useless friction. Even when Stephenson had proved the tractive power of a locomotive with smooth drivers upon a smooth rail to be amply sufficient for all ordinary purposes, still this power was supposed to be much less than it really was, and the influence of grades to be much more than has since proven to be the case.

This led to the English practice of sacrificing all questions of economy in construction, to making the road as nearly level as possible, and also, on account of the long rigid wheel base of the rolling stock, to making the curves as few and of as long a radius as possible. All the lines built in England were comparatively short. The country is nowhere particularly rough, and there never was any question of the amount of capital that could be used. Consequently, at an enormous cost of right of way and construction (about $160,000 per mile), the English railroads have very slight grades and no sharp curves.

As we have said before, these roads were the only examples and education our earlier railroad engineers had in the *art* of railroad location. This led, in the location of part of the Baltimore & Ohio Railroad, to the introduction of inclined planes, in order to overcome the extreme elevations. Before, however, any of them were built, the engineers had arrived at the conclusion that inclined planes were not practicable on a road having a traffic that demanded speed, and that might in time grow to great proportions, and also that if easy grades and curve were an absolute necessity to the running of railroads, with the topographical features of the country and the extremely small amount of capital to be had railroads would be a practical impossibility for many years to come.

But railroads were a necessity, and the only remedy was to make the construction conform with the amount of available capital, and this necessitated steep grades and sharp curves.

It was then practically demonstrated that there was sufficient adhesion between the drivers and rail to overcome any grade that was necessary, and by changing the construction of the rolling stock so as to do away with the long rigid English wheel base, it became possible to introduce curves of a radius of such a length that made comparatively cheap construction possible in almost any class of country. The precedents established in the location and construction of the Baltimore & Ohio Railroad changed the whole theory and practice of railroad location and construction, and with that as a starting-point, there was soon developed what has since become famous the world over as the American Practice of Railroad Location and Construction, by which is meant that the cheapest possible line shall be built that is in no way prejudicial to true economy and the speed and safety of the future probable traffic, and that the above shall be the only limit to the curves and grades that may be used. It was the making possible the running of trains over steep grades and around sharp curves that did away with the necessity of building the majority of the first located inclined planes, and since then has done away with them upon all roads of more than local importance and handling only one class of freight principally, such as some of the coal roads in Pennsylvania and some short roads for exclusively tourist travel.

One more remark before we leave this question of American Practice of Railroad Location and Construction. As we have said, its whole basis and foundation was laid by the first engineers of the Baltimore & Ohio Railroad, and up to the present time, except in a few minor and unimportant details, there has been no material advance made in the principles laid down by those engineers some 60 years ago, with nothing to guide them but their common-sense, habits of close application, and thoroughness in every detail, great powers of observation, and the necessities of the hour.

These qualifications were combined with a fixed determination in all things to arrive at a desired end in a satisfactory manner with simply the available means.

And they usually accomplished their object, and in such a satisfactory manner that 20 years after the location of the Baltimore & Ohio Railroad, Congress recommended to the engineers about to commence the location of a Pacific road that they should study the methods and principles used in the location of that road, and follow them as closely as possible.

CHAPTER XXXV.

PAPER LOCATION.

After an accurate contour map has been made of the section of country through which the railroad is to be located, it is a very simple matter to locate the line that in its general features shall be the best line upon this map.

One great advantage of the contour map is, that by means of it you have, as it were, a bird's-eye view of the whole section of country, with all the prominent topograph-

ical features clearly indicated. In this way it is possible to see at once the relative bearing of each, and examine with care the whole country from one or every standpoint. Although the minor details of the line have to be fitted to the ground in the field, and if an effort was made to actually locate a line in all its details from a contour map, without an accurate and personal knowledge of the country, the minor details would in many respects be extremely faulty, while the general direction might be all right. On the other hand, a line located solely by reconnoissance in the field, without the use of contour maps, undoubtedly would fit well to the ground over which it ran, in its minor details, but owing to the comparatively small area that could be examined at any one time, from any one place, the larger features in the location might possibly be all wrong. So that the only manner of procedure which in every case will insure the procuring of the eminently best line in both the larger and minor details is a combination of the use of the contour map, a thorough knowledge of the country from personal reconnoissance, and a fitting of the line to the ground in every detail in the field.

When an accurate contour map has been obtained, a study of it will at once settle what ruling grade is the most economical. Then, with this assumed grade, we locate a surface line on the map.

Suppose the contour lines are 10 ft. apart vertically, as is usually the case in railroad surveys, with the scale of the map 500 ft. to the inch, the assumed rate of grade 2 per cent. Then, for every 500 ft. of length, the line would rise or fall 10 ft.—that, is from one contour line to the next.

Set a pair of dividers at one inch or 500 ft., according to the scale of the map. Placing one leg at any desired point on any contour line where it is wished to start the location line, and with the other leg cut the next contour line either above or below. Then from this new point step to the next contour line, and so on, with the dividers always set at that distance; that, with the given rate of grade, will give a vertical rise or fall equal to the vertical distance between the contours. This is shown in Plate LVI. The contours are assumed to be 10 ft. apart vertically, and the rate of grade 2 per cent.

Setting the dividers at 500 ft. we start from the point A, and stepping from contour to contour, always with this 500 ft., we obtain a series of points A, B, C, D, etc., each succeeding one being 10 ft. lower than the one before it, and 500 ft. from it.—that is, a line drawn through these points will have a 2 per cent grade.

This line, as will be seen, is very irregular, and it would not be practicable to build a railroad upon it. Still this line will give the general direction which must be taken by the future railroad.

Using this line as a guide, and conforming to it as nearly as possible, the best general line can scarce be obtained upon paper.

In locating this paper line full allowance must be made for the reduction of the grade upon curves, and also the curves should be offsetted to allow for the introduction of the transition curves as shown at a, b, c, d, etc., Plate LVI.

In trying upon the map curves of different radii, in order to use the one best suited to the ground, the beginner will undoubtedly experience some trouble in the use of the dividers for striking the curves, although by a little practice great facility in the use of dividers can be acquired; and when one has acquired this facility they are in every way superior to the many other methods advocated by some locating engineers.

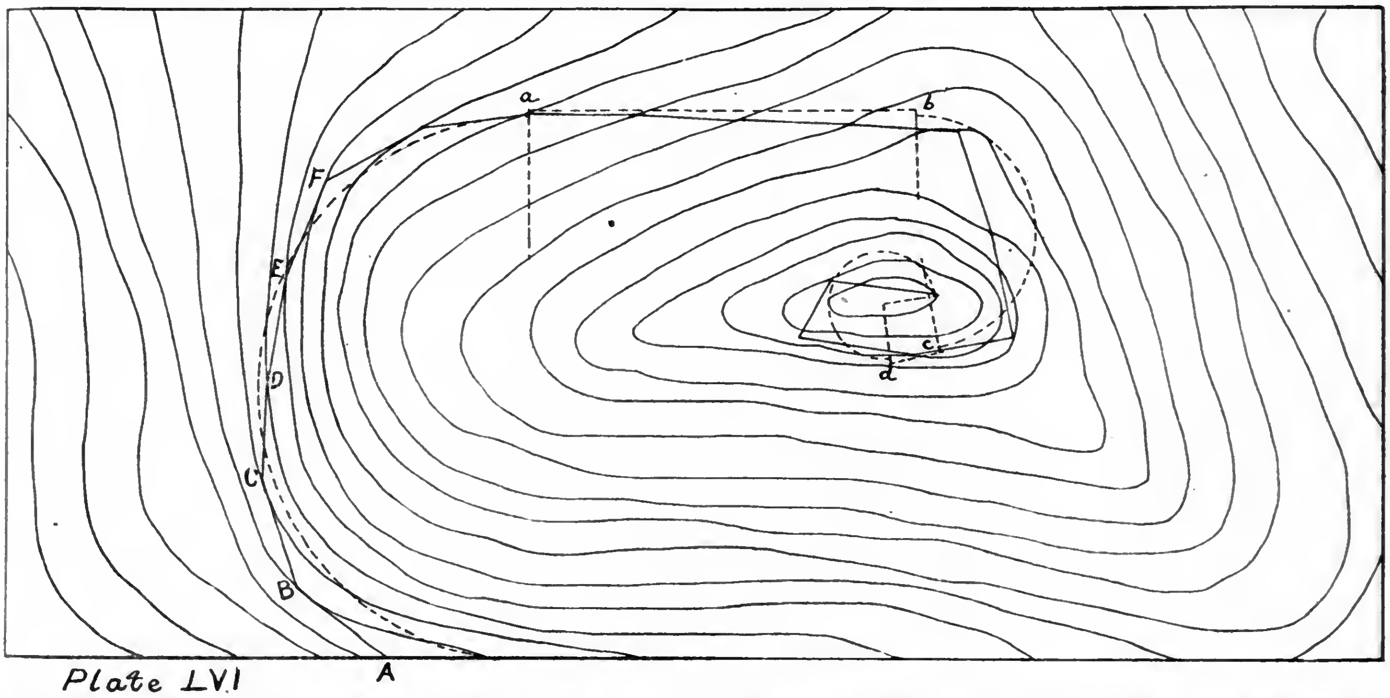


Plate LVI

The following method is often used, and for beginners has some advantages. Let Plate LVII represent a piece of vegetable tracing paper, or, better still, a thin, transparent sheet of mica; upon this draw with a very fine, distinct line portions of curves of different radii from a ½-degree curve to the minimum that will be used, decreasing the radius by ½ degree each time, the radii being the same scale as the contour map upon which it is to be used. In case the curves become too crowded, or there are so many lines as to create confusion, one-half the curves can be drawn in a reversed direction upon the opposite side of the tracing paper or mica.

All the curves upon one side should be drawn from the same center. In case a sheet of mica is used, the lines should be scratched with a fine steel point, and then, to make them distinct, those on one side should be rubbed in with black and on the other with red.

The radius or degree of curvature should be distinctly marked on each curve.

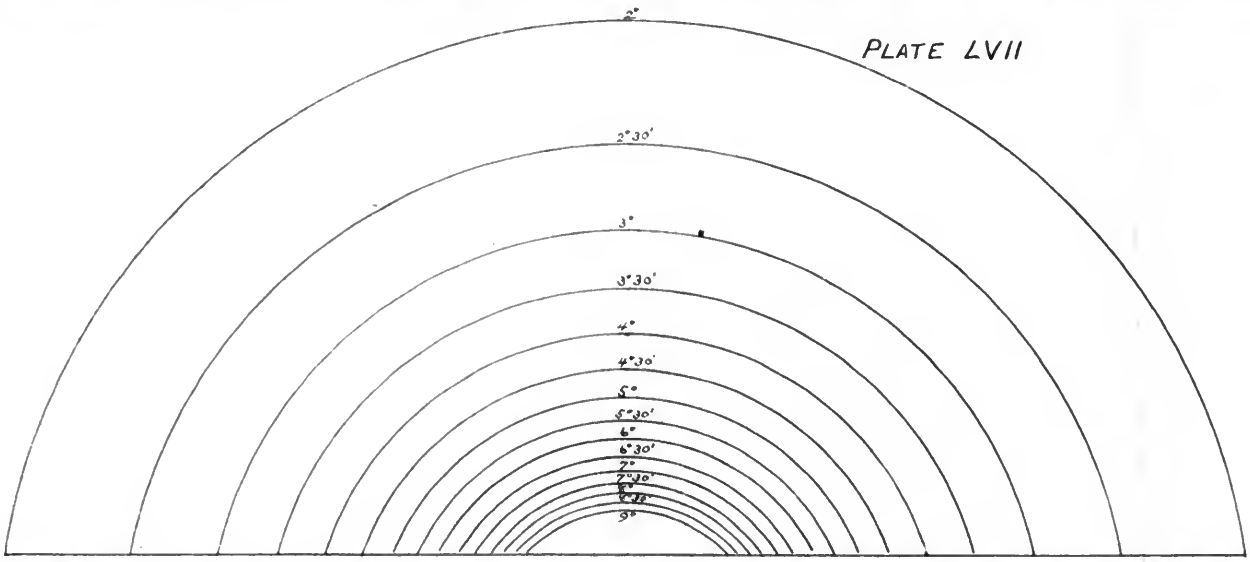
When a sheet of curves (or, as it is sometimes called, a curve protractor) has been prepared, it can be laid on the contour map and slipped back and forth until the appropriate curve has been decided upon and the position of the center pricked through.

Tracing linen should never be used for a curve protractor, owing to its expansion and contraction being very great. In mica there is practically no expansion or contraction, and tracing paper, when used in a room of moderately even temperature, is very little affected.

CHAPTER XXXVI.

FINAL LOCATION.

After the line has been located upon paper, careful notes should be made of its alignment in a field note-book, and from these notes the line run in on the ground. This



line in its minor details will not fit in every case to the ground, and where it is possible or probable that a better line can be obtained, trials of different lines should be made in the field, and the line accurately fitted in every detail. As this final line is run in stakes should be driven in at every station, and a plug with a tack point put in at every P. C., P. C. C. and P. T., and as often on tangents and curves as is necessary in order to always have visible from any tack point, one other in each direction that may serve as back-sight or fore-sight.

All of these plugs should be carefully tied in, as explained in Chapter X, care being taken to select the trees or other objects to which these points are tied, at a sufficient distance from the center line, that there will be no danger of their removal, when the line is cleared for construction.

By closely following the above advice, putting in plenty of plugs and carefully tying them, much time and labor can be saved, whenever it is necessary to pick up and re-run any part of the line, either before or after construction commences.

The elevation of each station should be taken, and their correctness verified by checking on the bench-marks that were established along the line on preliminary work.

A careful study should be made of all rivers and streams, as to the size of the opening necessary to pass the water.

Bench-marks should be established at all places where there is to be any masonry, bridges, or other structures.

From the level notes a complete profile should be plotted, and upon this the grade line established.

This is one of the most important and delicate operations connected with railroad location, and upon the judicious solution of the many problems to which it gives rise and which have been explained in detail in the foregoing pages, depends to a great extent the future success of the road.

On the finished profile should be shown clearly, by means of notes, the class and dimension of every culvert, bridge, trestle, etc., that will be built on the line. Every grade should have marked on it the rate of grade, and the points where the rate of grade changes should be clearly indicated. Along the top of the profile should be indicated the alignment, showing at a glance the P. C.'s and P. T.'s and also the direction of the curves, whether to the right or left, as we face in the direction in which the line is being run. In every cut or fill the material of which it is composed should be noted with as much exactness as possible. When the profiles are finished by the engineer in charge of the work of construction, or for his use, it is often convenient to have written on the bottom the elevation of each station, the elevation of the grade at each station.

The differences between the two show the center cut or fill, and the number of cubic yards of material in each station. On each cut and fill should be written the total number of cubic yards of each kind of material in each. Of course this classification of material can only be approximate at this stage of the work. In cases of very heavy work, however, where any error in the class of the material would be an item of great importance in the estimate of cost, there are very often tent pits sunk until solid rock is reached, and then, if deemed of sufficient importance, the tent pit is driven down to any required depth by means of the diamond drill or some other similar machine.

The advantage connected with the use of the diamond drill is that it cuts out a cylinder of the rock, leaving the cone intact, and is so arranged that at any desired point this cone can be broken off and extracted, thus showing exactly the material passed through.

CHAPTER XXXVII.

GRADES, CUTS AND FILLS.

After the establishment of the grades, the elevation of the grade at each station is calculated, and the difference between these elevations and the surface elevations at the same station gives the center cut or fill at each station—that is, the depth of the cut or fill that will be necessary to reach the elevation of the grade line.

These "center cuts" and "fills" should be copied into the

cross-section book that is to be used in the field for putting in the "slope stakes." The heights should be written in a column down the center of the left-hand page, with the sign + before those heights that indicate "cuts" and — before those that indicate "fills." When this has been done everything is ready for putting in the slope stakes in the field.

By the slope stakes are meant stakes driven into the ground on each side of the center stake, forming right angles with the center line at the center stake, and at the points where the slope of the sides of the cut or fill will cut the natural surface of the ground. Thus in Plate LVIII, figs. 1 and 2, let *E* and *B* be respectively two center stakes and *E G* and *B H* the center cut and fill. Then will *D F* and *A C* represent the position of the slope stakes—that is, the points where the slopes will cut the natural surface of the ground, when the road-bed is built.

The manner of putting in these stakes, or finding the side distances *D E*, *E F* and *A B*, *B C*, is as follows: The side what the material is of which the cut is composed. In the case of loose earth or sand the slope should be the same as a fill, or 1½ to 1. In gravel, hard-pan, etc., this slope can often be reduced to 1 to 1, and in some cases to ¾ or ½ to 1.

In rock cuts the material can often be taken out with a slope of ¼ to 1 or less.

Of course in every case there are two evils to choose between. If the slope is taken out greater than is necessary, there is a waste of money in moving a useless amount of material. On the other hand, when the slopes are left too steep there is an almost everlasting loss in continually clearing out the cut as it slides in after every rain, until the proper slope has been obtained. As this is much the greater evil, care should always be taken to give the sides sufficient slope, even if it should prove in the end that the material would have stood at a much steeper.

3. The natural slope of the surface of the ground. This we have to accept exactly as we find it in every case.

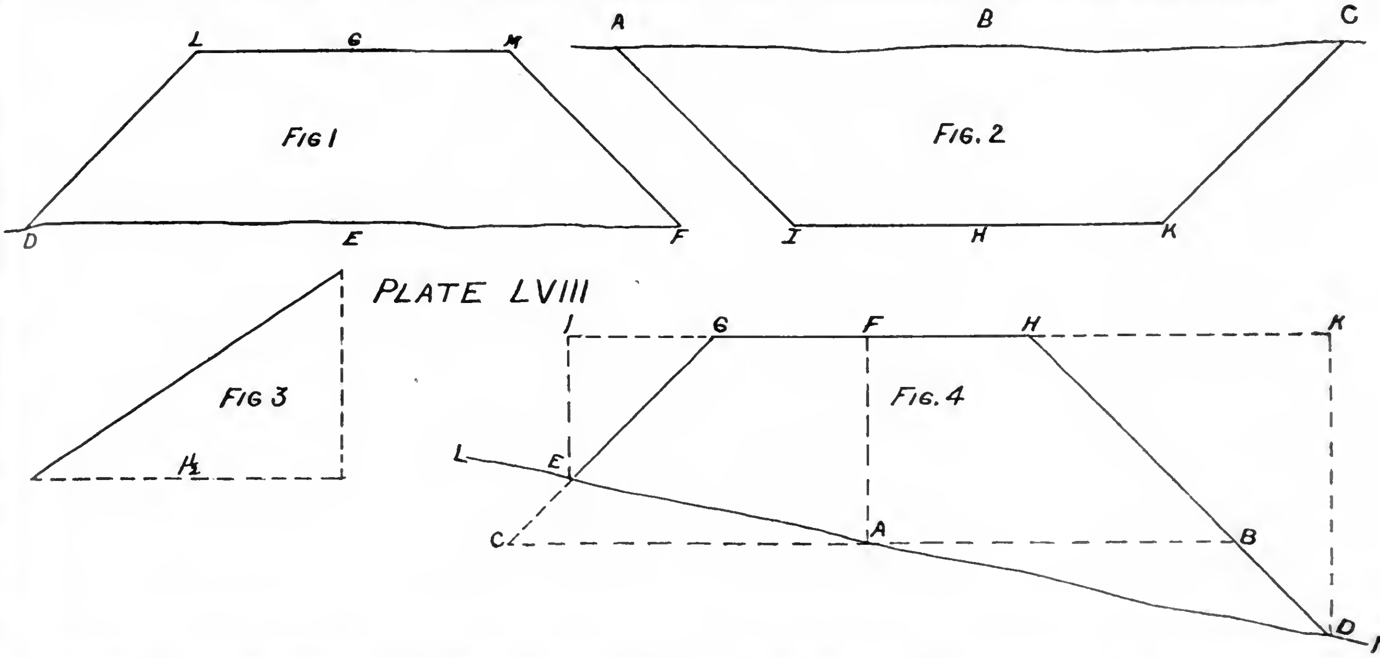


PLATE LVIII

distances or the distance each way of the slope stakes from the center stake depend upon:

1. The width of the road-bed, *L M* or *I K*.
2. The angle of slope given to the sides of the cut or fill, as *D L* or *J A*.
3. The natural slope of the surface of the ground, *D F* and *A C*.

1. The width of the road-bed for a single track road, of standard gauge in fill, is usually from 14 to 16 ft., and in cut from 2 to 6 ft. under to allow for ditches on each side. For double track it is 20 or 22 ft. and upward, with an increased width in cuts.

2. The side slopes. The slope of the sides of a fill, when made of loose material just dumped in, should always be as flat as 1½ to 1—that is, 1½ horizontal to 1 vertical (Plate LVIII, fig. 3). Even if the material, such as broken stone taken from a rock cut, appears capable of standing all right at a steeper angle when it is first put in, it is never safe to count on any continuance of this steeper slope, as in a very short time it will settle and run out at the bottom until it has assumed at least a slope of 1½ to 1, and in many cases more, some material requiring as great a slope as 2 to 1.

In the case of cuts, however, this is not the case. The slopes given to the sides of a cut depend in every case upon

Where the surface of the ground is horizontal, the setting of the slope stakes is a most simple matter.

The side distances will be one-half the width of the road-bed, plus the center height times the ratio of the side slope. Thus let the width of road-bed be 14 ft., center height, 10 ft., and side slopes, 1½ to 1.

Then the side distances would be

$$\frac{14}{2} + (10 \times 1\tfrac{1}{2}) = 22$$

Where the surface of the ground slopes, however, this is a rather more complicated matter (Plate LVIII, fig. 4). If the surface of the ground was level, with a road-bed *G H*, center fill *F A*, and side slopes, as shown in the plate, the side distances would be *C A* and *A B*. But *L A M* represents the surface of the ground; then the side distances would be *I G* and *H K*, and the slope stakes would be at *E* and *D*. If the surface of the ground was a true plane from the center each way, we could measure the angle of inclination and calculate at once the exact position of the stakes *E* and *D*. But even this would be a more or less complicated problem, and, as a matter of fact, the ground surface not being a plane, but very irregular, the angle of which is constantly changing, this method is not feasible.

(TO BE CONTINUED.)

NOTES ON RIVER CROSSINGS AND BRIDGE PIERS.

By M. Otagawa, M.E., Tokyo, Japan.

I.—GENERAL CONSIDERATIONS.

In a mountainous country like Japan, which is also full of running streams, a considerable difficulty is met with in carrying out engineering works. In determining lines of land carriage an engineer must, on the one hand, carry out his work so as to obtain the full benefit from economy of construction, and, on the other hand, to cause the least obstruction to the actual condition of the river in regard to stream and navigation. If the proper arrangements be not made, bridges and embankments become serious enemies to the works of river engineering. Our rivers are all, during the greater part of their course, rapid mountain torrents, and it is only toward the mouth they become sluggish and navigable. Even near the mouth many of the rivers have their beds very much elevated above the level of the surrounding country. For the purpose of navigation the river must be deep, but there is another object which is to be aimed at. Our rice-fields are to be irrigated by rivers, so that the level of such rivers must not be lower than that of the fields.

Such being the case, we have many examples of rivers whose beds are considerably elevated above the neighboring ground. The most noticeable examples of this kind are seen between Kobe and Osaka. Travelers by rail from Kobe to Osaka will remember that they passed through three short tunnels. These tunnels are under three rivers known as Ishiyagawa, Ashiyagawa, and Sumiyoshigawa. In these rivers materials in mechanical suspension were gradually deposited, and at the same time the inhabitants raised the banks. The result was that, when the railroad was to be constructed, the rivers had to be *tunneled under*.

In such cases, when the bed of the river is sufficiently high to be tunneled under, an engineer can carry out his work with comparative ease as long as a flood does not burst the banks. But in case there is not sufficient headroom to carry the line below, or when drainage is difficult from the general configuration of the ground, the river must be crossed by a bridge, and sufficient flood openings must be provided.

Although bridges may be classified under a great many heads, they may be divided into three principal classes—namely, arched bridges (or those of masonry), girder bridges (or those of iron or wood), and those on the suspension principle or the cantilever principle. Each of these may be again subdivided into many classes of different types, which are peculiarly adapted to a variety of situations and circumstances. There are certain situations for which one type of bridge would be as suitable as another. In such cases the choice is left to the judgment or to mere taste. As the span of a bridge increases, the selection is narrowed.

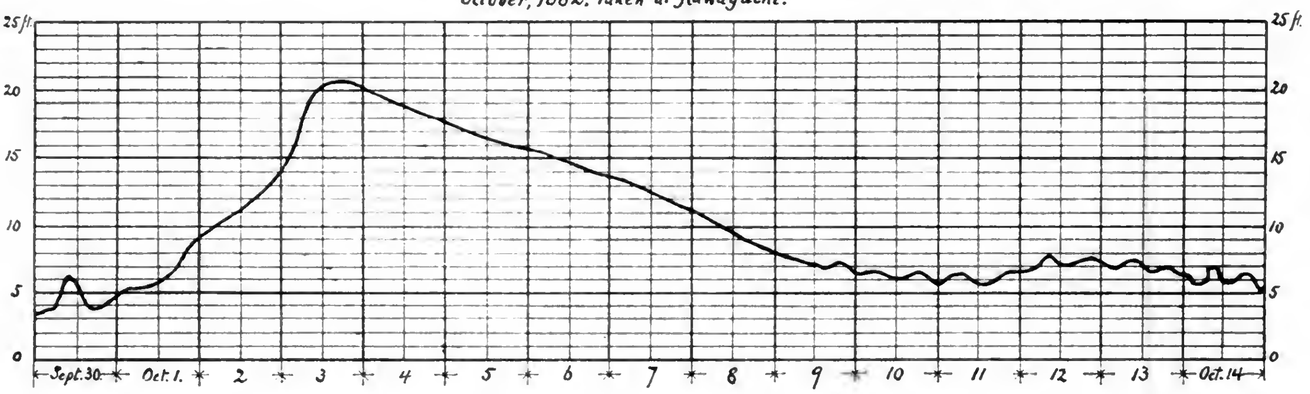
The different kinds of bridges should be chosen according to:

1. The nature of the river.
2. The nature of the traffic.
3. The level of the approaches in their relation to the river.
4. The abundance of certain materials, and their facility of transport and of workmanship.
5. The general features of the site.

In those situations where the traffic is continuous and heavy and foundations are easy, bridges of masonry are most suitable. But such bridges offer greater obstruction both to the stream and to navigation, as compared with other types of bridges, because in them the ratio of the thickness of the pier to the span is very great. For spans between 30 and 150 ft. an iron girder is most economical, and for shorter spans wooden bridges may be preferred to other types when the first outlay must be small. Suspension bridges, or those of the cantilever type, are to be recommended where the span is too great to be crossed by arches or girders at a reasonable cost.

Our present object of inquiry is how best to bridge over a river with the least possible disturbance to the regimen of the river. With a span of 100 ft. or thereabouts, and by reducing the thickness of the pier as much as possible, we will be able to cross most economically and at the same time in harmony with the regimen of a river which is subject to floods.

Fig. I. Diagram of Flood Level of Arakawa River. October, 1882. Taken at Kawaguchi.



In designing a bridge over a river, accurate observations must be obtained with regard to the level of the highest known flood and the actual condition of the river. Unless the observations be carried out by direct gaugings, the only source of information is to get the highest water level with respect to the levels of flood banks or some fixed works from the statements of people living on the spot.

II.—PHYSICAL CHARACTERISTICS OF RIVERS AND CHOICE OF BRIDGE SITES.

The phenomena of floods are the combined result of the irregularities of rainfall and of river-beds, the rain falling upon the ground faster than it can run off. The former is generally beyond human influence, except to a very limited extent as affected by forests, etc., but the latter is within the field of human operation. Little is yet known to us about this subject. Those rivers which have small storage room and flat beds readily overflow. It is possible to calculate the rate of rise in the rivers if we know the nature of the soil, the inclination of its surface, the rainfall, the evaporative power, and the direction of the wind. Floods on chalky soil are of rare occurrence, while in mountainous districts of primary rock their rise and fall is rapid. Our Japanese rivers are, in their ordinary state, merely thin bands of water, but the melting of snow or a continuous rainfall rapidly fills the river channel with an amount of water equal to a high multiple of its average flow. Again, many of our large rivers have their sources on the sand hills, which consist of decomposed granite or Syenite, and the result of clearing away trees in the hills is to wash down the sands and elevate the river-bed, so much so that a line of land carriage can be taken under the bed, as noted above.

In October, 1882, during my stay at Kawaguchi (on the Tokyo & Takasaki Railroad), I met with a great flood in

the Arakawa River, and the aspect of the flood presented several interesting features, to the particulars of which I am going to refer. The Arakawa, in common with other Japanese rivers, is occasionally subject to floods, and when it is submerged by flood waters, its volume is augmented to from five to fifteen times its ordinary flow. The greatest flood within the memory of the oldest inhabitant occurred in 1846. The flood of 1882 is said to have been 1.5 ft. lower than that of 1846, according to the almost unanimous statements of the people living in the neighborhood. I had good opportunities of making observations as to the rise and fall of the flood, of which a diagram is shown in fig. 1. When it occurred the temporary railroad bridge over the Arakawa was in process of construction and suffered damage, from which some important facts may be gathered.

As a general rule, in the Kawaguchi District there are signs of a coming flood. These signs are the prevalence of southeasterly winds, accompanied with long and heavy rains, which warn the inhabitants to take preparatory measures against coming disasters. But it was exceptional in the case of the flood of 1882. The general direction of the wind was northeast, and consequently the residents were far from expecting any flood. The rain began to fall at 11 P.M. on September 29, and it lasted till 9 A.M. on October 2. The rainfall, as recorded at Hongo Observatory, which was the nearest observatory, situated about 75 ft. above the sea-level, amounted in the aggregate to 7.642 in. during the time, and on October 1 alone the quantity was 5.333 in. The duration of the rain in the hilly districts at the upper part of the river must have been greater. At Kawaguchi the flood was first noticed at 10 P.M. on October 2, and the maximum height was obtained at 4 P.M. on October 3. The water began to fall as shown in the diagram.

The interpretations of the diagram of the flood wave are as follows:

1. At first the flood-water was carried off in the main channel, which is narrow (see fig. 2, which is a section, and fig. 3, a plan of the river at the crossing), so that the increase in height was somewhat rapid. But when the main channel was entirely filled with water to the line *A B*, then the water had to extend laterally, the consequence of which was to diminish the rate of rise until the sidewise extension was obstructed by the elevated land and flood bank. When these were reached, the rise became again sudden, as shown in the diagram.

2. In the falling stage the converse is the case. The reasons why the river resumed its ordinary state in a comparatively small number of days are: (*a*) Previous to the flood there was not long rain; (*b*) large quantities of rain fell not at the source of the river, but rather below, and (*c*) the direction of the wind was along the stream.

When the flood occurred the temporary railroad bridge was being built, the piles being of "matsu" (pine) from 32 to 40 ft. in length and 1 ft. diameter at the butt end; these were driven in about half length by a pile-driver, the ram weighing about 850 lbs., and the last penetration ranging from 0½ to 6 in. In addition to these piles, materials, such as rails, stones, bricks, earthenware pipes, timbers, etc., obstructed the water-way. These materials occupied no less than one-twelfth of the sectional area, at the time when the flood-level was highest. Moreover, in the center of the channel two pile-drivers 33 ft. high mounted on stagings must have formed a great obstruction to the current. Finally they were swept away by the flood. The concave side of the bank was scoured considerably, on account of the narrow, tortuous course of the river as obstructed by the gigantic temple of Zenkoji. The obstruction of the temple mound caused eddies of water, which struck upon the bank a short distance below, and the result was that the shore was scoured off. These facts bring into prominence the following particulars regarding the construction of a bridge:

Fig. 2. Section of Arakawa River at Temporary Bridge.

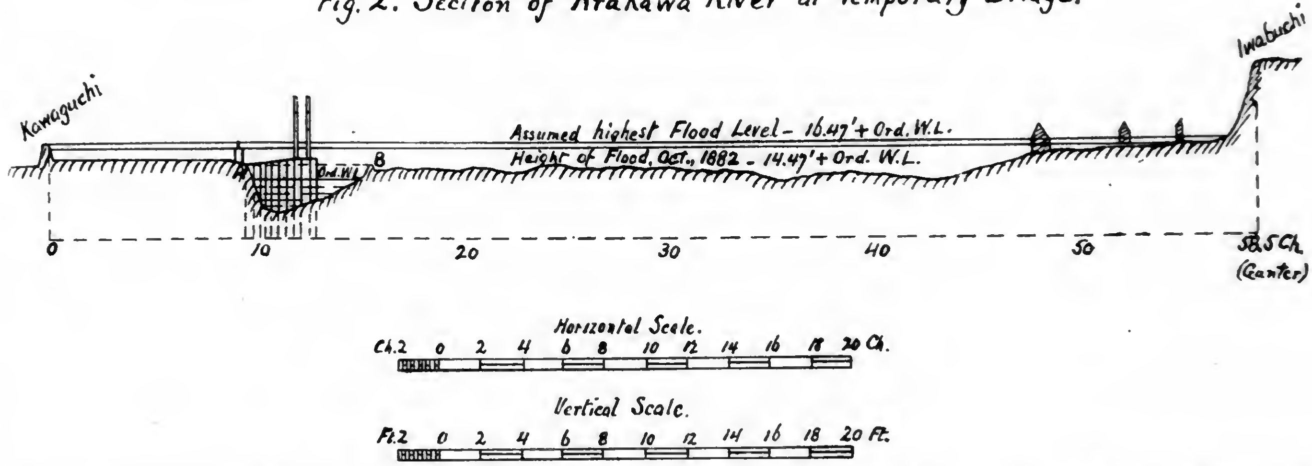
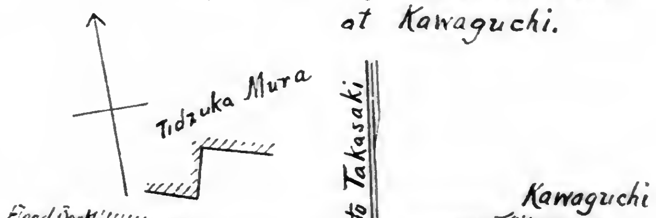


Fig. 3. Plan of Arakawa River at Kawaguchi.



1. No permanent obstruction, such as the piers of a bridge, should be built in the narrow, tortuous part of a river.

2. A pier should be sufficiently removed from a bank to

allow of the latter receiving only hydrostatical pressure as much as possible.

Besides the temporary railroad bridge, there are two road bridges of fragile construction, one about three miles above and the other about nine miles below the temporary bridge. The former is known as the Toda bridge in Nakasendo, and the latter as Obashi bridge in Senji. These structures are nothing more than wooden bridges of the usual Japanese type. Unlike the temporary bridge, they were not damaged, though the passage over the Nakasendo was suspended for a day. The reason was that the flood areas at the two sites are much greater than at Kawaguchi, and there existed no obstruction, such as the temple and the building materials.

Such being the features of the flood in the Arakawa, and the conclusions derived from it, I shall now enumerate some of the important points which engineers should aim at in selecting a bridge site.

1. A point of crossing must be chosen where the channel is permanent, otherwise some precautions must be taken.

2. That part of a river where the breadth is narrowed below and where it keeps a long, straight course should be chosen.

3. Sharply curved parts of a water-course should be avoided, and a straight reach should be preferred on account of the uniformity of the regimen. If this be not done, there will be augmentation of velocity of flow on account of the contraction of the water-way from the construction of a new bridge which causes scouring of the concave bank.

4. The locality of a crossing should be such that it will give a firm support for the foundation of a new structure.

5. The approaches of the bridge should not require heavy cutting or high embankment.

6. The narrowest section of a river is not the best section for a crossing, for it would not give a sufficient amount of water-way after the abutments and piers of the bridge are built, so that the section of a crossing must give greater flood-area than the narrowest section, at least by the aggregate thickness of the piers of the bridge and flood openings, if any.

7. The axis of the bridge should be placed at right angles to the thread of the current, or as nearly at right angles as practicable. In cases where a skew crossing is unavoidable, the angle of obliquity should not be greater than 70° to insure both solidity and economy.

Having these objects in view, the engineer should at first make a reconnoissance, and is required to make a careful survey of the watercourse and the flood banks. These surveys should be made for some distance, both above and below the place where he has to build a bridge. He must also make soundings and borings at different points of the streams in order to ascertain the nature of materials for piers and abutments. Information must also be obtained from the inhabitants as to the height reached by floods and the changes that the channel has undergone for ages, which were caused either by floods or by artificial means, such as the construction of bridges, dams, embankments, etc. This information, together with the survey, will enable the engineer to compare the relative advantages and disadvantages of the different places of crossing with respect to the probable effects which will result from the construction of a bridge.

The position of the crossing having been decided upon, the following points must be considered in constructing the bridge :

1. If the site chosen be not on a rocky bluff, the shore must be protected so as to keep the channel permanent.

2. A sufficient amount of water-way should be provided —that is, the lower chord of a girder should be above the highest flood-level, and the abutments and piers should not contract the water-way so as to produce any injurious results either to the bridge or to the river. In case of a road bridge, in order to have a sufficient amount of headway, the gradients may be formed accordingly toward the middle point of the bridge, the gradients being, of course, not steeper than the ruling gradient.

3. The headway and distance between piers must be sufficiently great to cause no obstruction to floating materials, such as ice, timber, etc.

4. The piers of the bridge should be placed parallel to the direction of the current in the main channel at least, and there should be provided suitable cut-water quoins at both ends. The size and shape of piers should be sufficiently strong, and at the same time of a nature to offer the least obstruction to the stream.

5. The foundation of the abutments and piers should be durable. In obstructing a certain portion of the water-way by piers, there is consequent augmentation of velocity of the stream, and the river compensates for the lost area by undermining its bed, so that we must ascertain to what depth the scouring will probably take place, and the foundations must be sunk sufficiently deep. In some cases it is necessary to protect the river-bed, in order that the foundations may not be washed out.

III.—WATER-WAY.

As suitable dimensions for water-way are essential to the durability of a bridge, the very first thing which we must know is the flood discharge of a river. During the hot season a great quantity of aqueous vapor is collected by a lofty chain of mountains, and as soon as the cool season sets in there is a continuous rain which causes floods in rivers. Such is the case more particularly in mountainous countries and in the vicinity of the sea. In Japan many of the large rivers overflow after long and heavy rains in spring and autumn, which last for many days and nights together. On the other hand, sometimes there is no rain for months, and rivers are dried up, and the only remains of watercourses then are mere threads of water. How different are the conditions of the watercourses in the two cases ! The shallowness of water will, perhaps, impede the crossing of the channel during the latter season of the year ; but it is apparent that the bridges and flood openings made under such a state of things are not suitable for the other case, when there are freshets. High flood banks along the stream proclaim the experience of ages, in which the inhabitants have struggled with the water. Again, gigantic stones and rocky beds furrowed into deep holes show that there must have been flood-waves at some other seasons of the year. In country districts we find rivers which are crossed by wading, the water being only ankle deep ; but after a heavy rain the passage is necessarily stopped on account of flood. Even in case of rivers which are crossed by bridges, the bridges are often swept away by floods.

Such being the general conditions of rivers which are to be bridged, the question is how to allow for the proper amount of water-way. In some cases valuable information may be gathered from the existence of old bridges at some distance either above or below the new crossing, in judging of the dimensions required for the new one. From careful observations and surveys, combined with information supplied by the inhabitants with respect to the highest flood-level, the engineer can ascertain the probable flood discharge of a river, which will give generally a fair result for the design of a bridge.

The discharge of a river is the product of its sectional area and the mean velocity. The former can be determined by soundings and levelings, and the latter, or mean velocity, can be obtained from the surface velocity reduced by a simple formula. First of all it is advisable to divide the cross section of a river into two or more compartments, according to the depth and character of the bed.

For the majority of Japanese rivers which are subject to floods, there are invariably two distinct compartments, the one being the main channel or the river proper, where water usually flows, and the other, the side spaces or forelands lying between elevated grounds or flood banks, as the case may be.

The physical characteristics of these two compartments are : *First*, the mean depth in the main channel is considerably greater than that in the side spaces ; *secondly*, in the former there is comparatively little obstruction, while in the latter there are trees, vegetation, and even buildings. Since lands lying on the sides of rivers subject to floods were untaxed or taxed only slightly, people built houses and temples upon it, and when they experienced floods of greater intensity, they made increased protection for their houses, and thus the obstructions in the side

spaces became greater and greater. Such being the marked differences between the two divisions of a river, the velocity and discharge should be computed for these parts separately, as if there were two different rivers flowing next to each other, which, of course, insures a greater probability of fairer results than taking the whole river at once.

The velocity with which the water passes over the river-bed gradually decreases from the deepest part toward the sides, the maximum velocity in the same longitudinal section being not at the surface, but at some depth below. There are various methods for measuring the surface velocities, among which the simplest and most common in practice is by observing the time which floats take for transit from one station to another, the distance between the two stations being known. The formula which connects the surface velocity and the mean velocity is

$$Vm = CVs.$$

Where Vm is the mean velocity and Vs the surface velocity, C is a constant varying from 0.8 to 0.85. Messrs. Humphreys and Abbott, during their Mississippi survey, found the mean velocity at once by making observations with a float consisting of a tin tube 4 in. in diameter, which was loaded with shot so as to be sunk under water through the distance equal to the hydraulic mean depth. In cases where there is no opportunity of ascertaining the velocity by direct measurement, the probable value of the mean velocity can be obtained by a formula connecting it with the mean depth, the surface slope, and the physical character of the bed of the river. The formula for velocity, in common with other hydraulic formulæ, is more or less peculiarly suited to the river for which it was originally intended, so that the local conditions of a river to which it is to be applied must closely resemble the original conditions. Nowadays Bazin's formula is generally used.

I will now state some forms of the formula which were adopted by authorities in calculating the discharge of Japanese rivers:

1. The formula used by Mr. E. G. Holtham, late Engineer-in-Chief to the Railroad Department, in calculating the discharge of the Toda-gawa,* is as follows:

A = the area of cross section in square feet.
W = the length of wetted perimeter in feet.
S = the surface slope (or length of channel to fall of 1).
K = a constant.
Vm = the mean velocity in feet per second.

Then, $$Vm = \sqrt{\frac{KA}{SW}} \qquad (1)$$

In the above formula Mr. Holtham assumed the coefficient both for the river proper and side spaces at 8.500, and for the latter compartment he made an arbitrary addition of 5 per cent. to the length of the wetted perimeter.

2. Mr. Van Doorn, late Chief Engineer to the Engineering Bureau, used the following form of Bazin's formula, which he reduced into Japanese measurements:

R = the mean depth of river in *Shaku*.†
T = the surface slope.
Vm = the mean velocity in *Shaku* per second.

Then, $$Vm = \sqrt{\left\{11785.7 - \frac{48615.6}{R + 4.125}\right\} RT} \qquad (2)$$

In calculating the discharge of the Arakawa at Kawaguchi, of which the section is shown in fig. 2, I applied the above two formulæ. The result obtained from (1) is 458,203,400 cubic feet per hour, and that obtained from (2) is 460,529,280 cubic *Shaku* per hour. These two results agree pretty closely. Each of the formulæ seems to be suitable for the Arakawa, and it would be generally applicable to other Japanese rivers whose physical nature bears a close resemblance to that of the Arakawa.

* The upper part of the Arakawa River.
† Shaku = 0.99421186909 ft.

(TO BE CONTINUED.)

JAPANESE RAILROADS.

(Dr. Ernst von Stein in the Vienna *Zeitschrift fur Eisenbahnen und Dampfschiffahrt.*)

THE Japanese people have, as is generally known, for more than a decade past earned for their country the reputation of an Asiatic Europe by their enterprise and progressiveness. Already their railroad system, though almost in its infancy, finds itself in the stage of approaching completion. Depending upon itself and very little on the enterprise of English, American, German, French or Belgian capital—as other Asiatic and South American countries have done—while toleration for foreign capital has been obtained after some difficulty, the work has been and is done chiefly with the capital or accumulated wealth of the Japanese Nation itself, and the first steps toward the construction of a railroad system were taken partly through the organizing work of the Government and partly through the awakening enterprise of the people, following the lead of the State. Europeans have contributed advice, it is true, but have taken very little part in the actual initiative.

It thus happens that by the side of a widely developed system of State railroad lines there is growing up an equally extensive system of private (company-owned as distinguished from State-owned) roads, the creation of which is due to the Nation itself.

If we follow out and study this independent and self-supporting enterprise of an Asiatic people, a contrast lies very near at hand. In India, that densely inhabited country, the English—who at home think the private ownership of railroads the only possible or desirable plan—have been forced to adopt the State railroad system to secure the building of lines, although the Indian people have been under European influence not 20 years only, like the Japanese, but more than 10 times that period.

In the beginning of the Japanese railroad system the State and private railroad systems have taken equal part. Hondo (Nippon), the chief island, where are the two capitals—Tokyo the new, and Kioto the old—and the southern island, Kiushiu, the battle-field of the last rebellion and the home of the most warlike Japanese race, have begun to provide themselves with railroads. Shikoku, the neighboring island, is still without them, but the island of Yesso—the Japanese Northland—has already a line which runs from the coal-fields to Sapporo, the capital, and thence to the port of Otarunai.

The chief interest attaches to the extensive system now under construction, with Tokyo as its starting-point. The last year (1887) was marked by the opening of several important roads, and a brief review of that year will give us a picture of the present condition of the railroads of Japan.

Three lines are—and will be to all future time—the leading railroads of Japan. The first runs from Tokyo to Yokohama, the chief port for foreign trade, which is on the Gulf of Tokyo, in the western part of the island; this is a State railroad. The second runs from Tokyo northward, and is a private or company railroad. The terminal stations of these two lines in Tokyo are not far from each other, and just outside the widely extended limits which the city occupies, with its million inhabitants, the two are connected by a belt line. The third line, between the other two, reaches out to the northwest to Takasaki and the province of Maebashi, the famous center of the silk industry.

While the first of these lines will unite Kioto and the whole western part of the kingdom with the capital, the second will run through the whole extent of the long, narrow northern end of the island to its extremity, and will be the connection with the island of Yesso. The third is the starting-point for the Nakasendo line, which will run—parallel but not near to the Tokaido line—through the heart of Japan over the mountains to Kioto and the Biwaku Lake, reaching what is industrially and historically the most important district of the kingdom; a northern branch will lead from Shinanogawa to Kashiwasaki and Niigata, the last a port on the Japanese Sea, which divides Japan from Corea and the Russian territory on the Asiatic Continent.

While Tokyo is thus the center of a radiated or wheel-like system, a similar system of lines has been begun by Kioto, the ancient capital, which has by no means abandoned its rivalry with the newer city, but is in the field also in the modern development of the country, so that its railroad system will be an important factor in the future. The port of Kobe, which may possibly overshadow Yokohama in the future, when its railroad connections are finished; the ancient manufacturing city of Osaka, the center of an important part of the Government business, the mint and the arsenal being there; the neighborhood of the Biwaku Lake, around which great silk and other industries are concentrated; the nearness of the port of Tsuruga, one of the few good ports on the Japanese Sea—all these have importance enough to make the completion of the Kioto system and the connection of the two capitals a welcome event to both.

It must also be noted that the land route from Tokyo to the western end of Nippon and the island of Kiushiu must pass through Kioto. It is not impossible that hereafter, following the example of the Brooklyn Bridge at New York, a railroad bridge may span the narrow Shimonoseki Strait between the two islands, so that trains will run directly from Tokyo to Nagasaki, reducing the time between the two cities. This would have a bearing on commerce with Europe also, for the railroad haul from Nagasaki to Yokohama, about 1,000 kilometers, would reduce by so much the ship voyage.

To go back a little, we find that the first railroad authorized in Japan was the Tokaido line; the first section of this built was the short but important road from Tokyo to Yokohama.

The exorbitantly high cost of this little road, which was in the hands of English engineers, contractors and workmen, taught the Japanese the valuable lesson that they must rely on their own work as much as possible. In fact, the present extension of the Tokaido road from Yokohama, and the other new roads also, are located and built by Japanese engineers and workmen, with but very little help or supervision from foreigners. Even for the iron work of the bridges and other structures only the material has been imported, the construction and putting together having been done in Japan.

The past year (1887) was one specially marked by new extensions and openings, as shown below.

On July 11 the first extension of the Tokaido Railroad, from Yokohama to Kodzu, 48 kilometers, was opened. On July 30 there was opened by the Nippon-Tetzudo-Kaisha—which is the Japanese private railroad company, the second mentioned—the section from Kuroiso to Koriyama, 64 kilometers; and on December 15 a further section from Koriyama to Shiogama, 130 kilometers, making 242 kilometers in all.

It is of interest to follow the average yearly opening of railroads in Japan from the first beginning up to the present time, which has been as follows:

1868–1877, inclusive	14.4	kilometers.
1878–1880 "	8.0	"
1881–1883 "	57.6	"
1884–1886 "	103.6	"
1887	141.7	"

It is now possible to travel in 12½ hours from Tokyo to Sendai, the nearest frequented seaport on the Pacific Ocean, a journey of 344 kilometers, which until recently took four or five days.

In a short time the connection will be completed by rail with Nambu and with Aomori, the most northern port of the island, situated opposite Hakodadi on the island of Yesso. The Tokaido line will also be finished soon to Osaka.

Finally it is well to note the number of charters for private (as distinguished from State) railroads which have been actually granted. These include the following:

1. The Ryomo-Mito line, which is to run to the province of Mito, the home of a powerful race of Daimios related to the reigning family.
2. The Sanyo line, from Kobe by Okayama and Hiroshima to Akamagaseki; this is an important line, which, running along the south coast, will connect the central lines with Cape Shimonoseki at the extreme western point of the island, and will furnish a connection with the future system of the island of Kiushiu.
3. The Kiushiu line, from the port of Moji, opposite Cape Shimonoseki, to Kumamoto, a historic fortified city, which was the stronghold of the imperial army in the last rebellion.
4. The Osaka line, from that city to Imai in Yamato and thence to Nara-Wakayama and Yokaichi.
5. The Kwansei line, from Otsu to Yokaichi, from Kioto to Miyazu and from Fushimi to Nara.
6. The Sanuku line, from Marugame in Sanshu by Tadotzu to Kotshira, a line on the island of Shikoku.
7. The Koshiu line, from Gotemba by Kofu to Matsumoto in Shinshu, one of the ancient strongholds of the Shioguns.
8. The Kofu line, from Tokyo to Hatsoji.
9. The Yamagata line, from Shiroishi to Oshida.
10. The Nikko line, from Utsonomiya, a station on the great Tokyo-Sendai line, by way of Imaichi and Sagashimura to Shikanuma; in Nikko, on this line, there is the most famous and beautiful temple in Japan, which the railroad will make accessible to travelers, so that a large passenger business is expected. This line will also, by a short branch, be brought into connection with Maebashi, and through that place with the important Tokyo Takasaka Railroad.

Thus in a short time Japan will be provided with an extended railroad system, built by native capital alone. In fact, at the present time a railroad enterprise there—as it was in England in the early days—appears a veritable Eldorado for capitalists. The private line of the Tokyo-Sendai Company is now paying over 10 per cent. interest, and it has besides a Government guarantee of 8 per cent.

Nevertheless, in the natural course of events there will soon arise questions which must be settled, and which will spring from the competition between the railroads themselves and between the railroads and the water lines, which will always be an important factor in a country which has such an extended coast line, and so large a part of which is accessible by water.

The rate questions and the rate wars which have made so much noise and so much trouble in Europe—and in America also—are as yet unknown in Japan; but in that country also they will certainly come, and will have to be fought out as in our western countries—to a better and more satisfactory conclusion, it is to be hoped, than we have yet been able to reach.

GEODETIC SURVEYS OF ITALY.

THE geodetic survey of Italy, now nearly completed, has been executed in the most thorough manner, the work having been in capable hands and carried out with the most approved modern instruments and methods of observation and calculation.

The work was begun soon after the present kingdom of Italy was formed; it is in charge of a commission composed of members appointed from the Government departments most directly interested—the Ministries of War, Marine, Public Works, and Agriculture—and of the directors of the principal astronomical observatories.

Several bodies have had a share in the work: The Military Geographical Institute in Florence, the Hydrographic Office of the Navy at Naples, and the observatories at Milan, Padua, Rome and Naples.

The most prominent share has been taken by the Military Geographical Institute, which has furnished the greater part of the men and material for the work. This Institute is a development and enlargement of the Topographical Department attached to the General Staff of the Piedmontese Army, which dates back to 1814.

The work done under the direction of the Commission has been divided into four branches:

1. Trigonometrical and geometrical, including the measurement of base-lines, actual leveling and triangulation, determination of sea levels by observation, etc., etc.
2. Astronomical, including determinations of latitude, of azimuth, of differences of longitude, of intensity of gravity, etc., etc.

3. General work, intended to combine the results of the different surveys.

4. Publications, made with the object of rendering the results obtained accessible to the public and especially to the scientific world.

The work done is so arranged that it includes not only the geodetic surveys, but also the topographical and other work necessary in the preparation of the maps used by the Army, the Public Works, and other departments of the

4. The Phototechnic, which has charge of the engraving work, and which follows and studies the latest developments of photo-lithography, photo-engraving, etc.

Experiments are now being conducted with reference to the value of photography in surveying, especially in difficult and mountainous country.

The system of triangulation—now extended over the whole peninsula—is well shown by the accompanying map, which shows the primary triangulation and the several

GEODETIC SURVEY OF ITALY.

Government. There are now in preparation two large maps of the country which will be among the finest ever executed. One is a topographical map on a scale of 1:100,000, and the other a map for general purposes on a scale of 1:500,000.

The actual work as organized is in four divisions :

1. The Geodetic, by which is done the actual work of triangulation, measurement of bases, etc.

2. The Topographic, in which is done the topographic and general work.

3. The Artistic, in which the work of plotting the surveys and making the maps is developed.

base-lines. For this map we are indebted to the *Revista di Topografia e Catasto.*

It will be observed that besides the lines in the mainland and in Sicily and Sardinia, a line has been carried across the Mediterranean to Tunis, in Africa. This line was run in 1875-76, some time before that run from Spain to Algeria.

Six base-lines have been established and measured on the mainland and one on the Island of Sardinia. There is still a small gap to be filled, but this will be very soon eliminated by the establishment of an additional base-line near Grosseto in the Tuscan Maremma. The general rule

which has been adopted is to establish the base-lines at a distance apart equal to about 20 of the primary triangles.

The work of observation and calculation is now nearly completed. It is believed that by the use of the best instruments, by careful observations and by complete systems of checking both in observations and calculation, the errors have been reduced to a fraction so small that they may be practically disregarded.

Arrangements have also been made by the Survey to co-operate with similar work in other European countries, in order to further as much as possible the great object of all geodetic surveys, the determination of the form and surface of the earth.

A new arrangement which may be noted in this connection is the recent appointment of a Consulting Board, composed of representatives appointed by the Ministries of Agriculture, Commerce, Public Works, War, Marine, Public Instruction, and Finance. The powers of this Board are advisory only, and the object of its creation has been to secure co-operation between the different departments, and to arrange the engineering work of all so that it may be carried out in the most economical and effective manner, and that there may be no unnecessary duplication of work. At the same time the work of the Board does not interfere with the individual departments.

Although only established a little over a year ago the work of this Consulting Board has already had excellent results. It may be suggested that a similar body might be established in other countries as well as in Italy, with much advantage to the public service.

FRENCH OPINIONS OF AMERICAN CITY ENGINEERING.

Les Annales des Ponts et Chaussées in its last number publishes the summary attached to the report made by MM. L. Le Rond and L. Combarnous, engineers who were sent some time ago by the Department of Ponts et Chaussées on a visit of inspection to the United States. The conclusions of these gentlemen on railroads and other transportation matters have already, to a great extent, been anticipated, but there is in the report a chapter on American municipal engineering which is of interest, as showing the impression made by our city works upon the minds of educated French engineers, whose special training in the department which they serve has made them experts in that class of work. The report is as follows :

We were struck in the large American cities by the contrast which existed between the public streets, usually wide, well laid out, and lined by handsome buildings, and the poor appearance, and even the dirtiness of the pavement of the streets. The streets there are almost without exception defective, rather, however, from want of care in maintenance than from imperfection in the first construction.

The pavement is generally made of small blocks of hard stone with very open joints. Sometimes—notably on certain parts of Broadway in New York—these blocks rest on a foundation of concrete, and the joints are closed with coal tar. In Chicago, before the Board of Trade Building, the pavement is made of asphalt and pebbles. In many cities, notably in Buffalo, in Chicago, in Detroit, and several other cities on the Lakes, extensive use has been made of pavements constructed of round blocks of wood.

In the stone pavement the impermeability of the foundation, the almost complete absence of proper arch to the roadway, and especially the little care taken in maintenance and cleaning, have resulted in a very bad condition, and the streets are almost always covered with black and slippery mud.

The wooden pavements are very much better, as a rule.

The sidewalks are usually of flag-stones, and very little importance is attached to keeping a good surface or smooth joints ; consequently, little streams frequently establish themselves, the borders of which are more or less well defined, and which carry with them dirt and refuse, sometimes giving the passengers much trouble. Nevertheless, it is only fair to say that this custom does not much disturb Americans. The limits of these streams are usually found near the borders of the sidewalk, and it is customary in America to cross the roadway only at the intersection of the streets, where there are usually placed cross-walks which are a continuation of the sidewalk. These cross-walks are, besides, the only place where one can avoid the mud in wet and thawing weather, and where there are usually stationed policemen to make way for foot passengers when the road is crowded with vehicles.

The telegraph-poles, which sometimes carry hundreds of wires, and which do not respect even the richest and handsomest streets, give to American cities and streets an appearance original, it is true, but hardly beautiful.

The handsomest cities in America are, with the exception of Washington, which possesses very handsome avenues paved with asphalt, San Francisco, Baltimore, and the Lake cities, Cleveland and Detroit, which are distinguished by their beautiful avenues planted with trees, and their handsome residences surrounded by gardens. Certain quarters of Boston, New York, Philadelphia, and Chicago also deserve credit.

There is, however, no city in America which can compare with our large cities, either for the excellence of its pavement or the beauty of its streets.

The cities are in general furnished with very insufficient systems of sewerage, this being especially the case in New York.

As in the United States the system of passing everything into the sewer is generally employed, this results in stormy weather in very much inconvenience, and sometimes in very unseemly deposits in the streets. Moreover, in summer, when there is an insufficient circulation of water in the sewers, they often give out disagreeable and offensive odors.

The sewers generally discharge directly into the rivers in the neighborhood of the docks.

In Boston before 1875 there was a very imperfect system of sewers. Those first constructed were small and had become insufficient in consequence of the growth of the city. In the newer quarters, situated upon a level plain, the sewers had little or no fall, and at high tide were flooded with dirty water which washed back the impurities and formed accumulations continually increasing, sometimes constituting actual dams.

In some places swinging valves had been tried to prevent the backing up of the water from the bay, but the ebb-tide, very little assisted by the current from the small rivers which fall into the bay, had not sufficient force to carry away the deposits which the flood-tide brought up upon the banks surrounding the city. The result was, in summer, very offensive and disease-breeding emanations.

Moreover, at high tide the foul water was not able to flow out, and accumulated in the sewers, which were usually badly ventilated, so that the gas rising from them was forced back into the houses.

To remedy this state of things there has been constructed first, a collecting sewer, 3¼ miles in length, to which could be given only the insufficient fall of 0.0005 per meter, and which discharges into a terminal well or basin 14 ft. below mean low tide. The sewage water next passes through a filter in the form of a strainer, and is lifted by a pump to the height of 34 ft., thence passing through a syphon to a reservoir situated on Moon Island in the bay. The sewage is there received in large reservoirs, and is discharged on the ebb-tide at a point north of the island where there is a current of about one knot an hour which carries everything out to sea.

The machinery includes two compound engines of the Wooster system, running at a speed of 12 revolutions per minute, and each operating a direct single-acting Leavitt pump. These engines are each of 300 H. P., and their duty is from 25,000,000 to 35,000,000 gallons per day.

There is, besides, an auxiliary plant consisting of two Worthington pumps, each having a duty of 25,000,000 gallons per day.

At the discharge of the pumps the sewage water runs through two depot sewers about one-quarter of a mile long, which are intended to prevent the carrying of solid matter into the syphon, which is carried under the bay at a depth

of about 140 ft. below mean tide. These sewers are cleaned by a valve-boat. If deposits form in the syphon they are cleared away by a ball-cleaner.

In the interval between two tides the reservoirs on the island receive, on an average, 12,000,000 gallons, and they can be emptied in 30 minutes. The amount collected sometimes increases to almost twice the average, and it can then be discharged usually in 40 minutes.

The city of Providence has also recently improved its system of sewers; the arrangements which are there applied under the system of discharging everything into the sewer, differ very little from the methods used in England.

The city of Memphis on the Mississippi formerly possessed a very imperfect system of sewers, to which they attributed the epidemics of yellow fever in 1867, 1868, and 1869 Since the sewers of that city have been reconstructed the yellow fever has never been epidemic.

The same result has followed in New Orleans.

The city of Denver did not exist in 1860; in 1886 it had 65,000 inhabitants. The construction of sewers was begun in 1880, and the expense had increased in 1886 to $354,000. The system there applied is original, the notable point consisting in the use of automatic apparatus for cleaning or flushing the sewers. The ordinary discharge of water is not sufficient to give a continuous current or prevent deposits, but under this arrangement the water is retained in flushing cisterns and discharged at intervals, producing a rapid current, and washing out the sewers so as to dispense with any other cleaning.

This system, which was devised by H. C. Lowrie, City Engineer, is very simple. It consists of a cistern where the water collects, which is furnished with a discharge tube in form of a syphon, closed by a valve, which is a rubber ball filled with sand. After each cleaning this ball falls back on its seat and closes the pipe; when the pressure of accumulated water increases to a sufficient point the ball is raised and the discharge made.

This system could without doubt be used in many cases to great advantage with us.

Americans, generally, are great consumers of water, for washing and other purposes, and ice-water is especially their favorite drink. For this reason the cities as a rule have spared no expense in procuring an abundant supply of water of good quality.

The city of New York constructed, when its population was still small, an aqueduct from the Croton River carrying water from that river to a reservoir in Central Park. The old aqueduct could furnish 118,000,000 gallons per day, but in consequence of the growth of the population it had become necessary to force it to its full capacity, and by thus increasing the work its solidity was considerably affected.

New works are now actually in progress, including the construction of an aqueduct 33½ miles long to carry 250,000,000 gallons a day to the city, or 100 gallons a day per inhabitant on an established basis of 2,500,000 people, a figure which, it is expected, the city will reach in a few years. The aqueduct has, in fact, a full capacity of 320,000,000 gallons in order to supply not only the city proper, but the Annexed District recently added to the city.

This new aqueduct will be supplied by the construction of what is known as the Quaker Bridge Dam, which will be 277 ft. high and 1,422 ft. long, and which will largely increase the amount of water retained in the storage reservoir at the starting-point.

The city of Boston consumed in 1885 about 32 344,000 gallons of water per day on an average; this was brought from the Sudbury River, Lake Cochituate, and the Mystic River, and the supply was 71 gallons per inhabitant per day. The water-works at Boston are widely scattered, and it would be impossible to give in a brief space any idea of them. We can only say that additional works, completed in 1885, consisted of several earth dams over 30 ft. in height protected by concrete and riprap, and several conduit-bridges, one having an arch of 130 ft. The object of these works is to increase the supply to 40,000,000 gallons a day.

It is well known that the celebrated Cabin John Bridge was built in 1859 by General Meigs as part of the aqueduct which carries the waters of the upper Potomac to Washington. This admirable work is, after 30 years, in a perfect state of preservation, and does not show any of the cracks so often seen in works of this class.

As a rule the cities take their waters from rivers, as much as possible above the thickly inhabited points, or from lakes. At Chicago the water-works get their water from Lake Michigan, through two tunnels, running out two miles into Lake Michigan, and it is distributed through the city without any intermediate reservoir.

These examples will be sufficient to show that the problem of water supply has received, according to the circumstances, solutions much varied and sometimes very remarkable.

Lighting varies much, not only in different cities, but often in one city and in the same streets. In most towns the streets are lighted by gas, but every one is allowed to put up his own light, and in many cases advantage is taken of these private lights to reduce the city expenses. Sometimes, even, they are content with the light from the stores, and the streets of American cities present at night a very curious appearance. One sees not only gas-lights but different systems of electric lights, carried upon all sorts of supports, and it can often be said that the passenger is more dazzled and blinded than helped.

Large squares, as, for instance, Union and Madison squares in New York, are sometimes found lighted by a circle of electric lights placed on top of a high mast. These can be lowered when it is necessary to change the carbons.

This system has been applied to a great extent in Detroit, where the whole city is thus lighted by what may be called electric chandeliers, carried upon iron towers of very light construction about 60 meters in height and about 200 meters apart.

These throw out a steady light, very much like that of the moon, and give the beautiful city of Detroit an appearance entirely unique.

In Cleveland, where are the workshops of the Brush Electric Company, there is an electric light tower 250 ft., or 75 meters in height.

The use of the electric light is now spreading very rapidly in America for lighting railroad stations, workshops, streets, and hotels, and is becoming common in private houses.

There exist in American cities many companies which furnish electricity to houses and buildings, and there have been formed in many cities electric companies which distribute electricity furnished by the Edison, Brush, and other machines.

In New York a company has been organized on a large scale to distribute steam. It has a plant of 42 Wilcox boilers of 250 H. P. each, and has put down over six miles of pipes of 15 and 16 in., and 13 miles of lesser diameter. In these pipes it is estimated that the loss of heat is not over 5 per cent. So far as we are informed, however, this company has not been yet financially successful.

In some Western cities, as in Pittsburgh and Buffalo, a commencement has been made in substituting for coal the natural gas, which is discharged in immense quantities and at very high pressure by wells similar to those bored for petroleum. This gas is distributed through underground pipes to the points where it is consumed. In Pittsburgh, especially, it is used in large quantities both in manufacturing establishments and in private houses for domestic purposes.

In conclusion, it may be said that, if we recognize the difficulties under which they have had to labor, and the immense works which it has been necessary to construct in a short time, the American people have shown qualities which will make them the first engineers in the world. Their great superiority is in their quick appreciation of circumstances and the advantage which they take of them, and also in the fact that they are free from preconceived ideas. For them every problem is soluble, because they always take care to put it well. While their cities are in some respects inferior to ours, it is more because of their rapid growth and the lack of time, than because they do not appreciate the situation, and have not the ability to meet it.

NOTES ON STEAM HAMMERS.

BY C. CHOMIENNE, ENGINEER.

(Translated from the French, under special arrangement with the Author, by Frederick Hobart.)

(*Continued from page* 458.)

CHAPTER XXI.

THE COCKERILL 100-TON HAMMER.

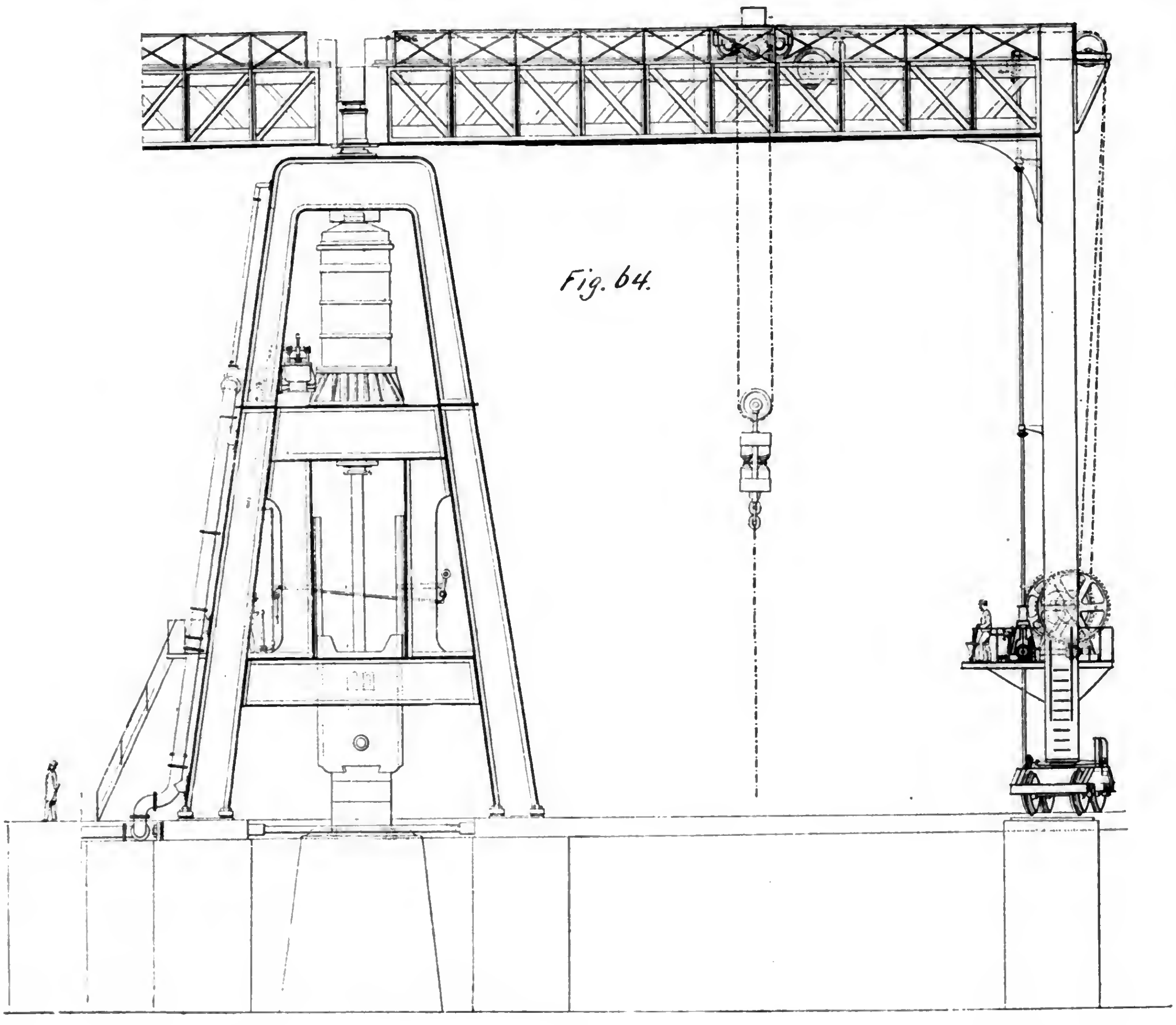
THIS single-acting hammer was built by the Société John Cockerill, at Seraing, Belgium, for the Terni Steel Works in Italy. A very fine model in wood was shown at the Antwerp Exposition in 1885. Of the accompanying illustrations, fig. 64 is an elevation, fig. 65 a side elevation, and fig. 66 a plan. These illustrations give an idea of the form and dimensions of this enormous tool, which was especially made to forge heavy guns and armor-plates for ships, and generally forgings of the very heaviest description. The engravings show also the arrangement of cranes, etc., by which these enormous forgings are handled. Fig. 67 shows the piston-rod and hammer on a larger scale.

We cannot properly describe this hammer without speaking also of the arrangement of the reheating furnaces and of the building which shelters it.

There is at Terni a fall of water of considerable volume, and of a height of 180 meters; this is used to drive four air-compressors, which can furnish each 24 hours 50,000 cubic meters of compressed air, having an effective pressure of 5 atmospheres. The motive power of the hammer is therefore compressed air, and not steam, as is usually the case.*

The hammer rests upon two enormous masses of masonry carrying two foundation plates upon which the frames are placed. Immediately below these foundation plates is a seat composed of a block of cut stone 1.000 meter thick, and below this again is a mass of masonry set in cement.

The foundation plates are in two parts, joined together by heavy bolts, and each of these two parts is held in place by eight large bolts, four passing through the legs and four at the corners of the plates. These bolts have a section of 0.180 square meter, and run down 6 200 meters into the masonry foundations: at that depth they pass through a guard-plate of iron 0 125 meter thick, and are held by keys bearing upon this plate.



THE COCKERILL 100-TON HAMMER.

The anvil-block is completely independent of the frames and supporting plates. Its total height is 5.500 meters, its general form being that of a truncated pyramid, with a rectangular base of 7 by 6 meters in size. The top is square, each side being 3 600 meters in length, and the total weight is 1,000 tons. Owing to the difficulty of moving so large a block it was necessary to cast it in place, and this operation succeeded so well that it is hoped that the block is entirely sound, and will be able to resist properly the shocks which it is called upon to receive. This anvil-block rests upon a foundation of oak blocks solidly bolted together.

* The Allevard forges in Isère, France, have also large hammers worked by compressed air.

The frame, built entirely of wrought-iron plates and angles, carries the steel slides and the cylinder above.

Instead of employing two legs of cast iron for the lower frame, according to the general practice, the designer of this hammer preferred to use four legs, as stated above, of wrought-iron plates and angles giving very great resistance. This method of construction, which gives the tool a very light appearance, had been used since 1880 by M. Arbel for several hammers, among which there is the 40-ton hammer for forging wheels, which has been described above. This hammer has acted very well, and has not required any repairs, which would certainly have been the case if an ordinary cast-iron frame had been used, and had been called upon to support the very heavy blows which are necessary in this kind of forging. Moreover, this arrangement of four legs is much preferable to the cross-pieces which brace the frame together. This lower part carries also the apparatus for distributing the compressed air, which is single-acting and is composed of two balanced valves with double seat. The diameter of the cylinder is 1.920 meters, and its total height 6.500 meters.

The movement of the valves, and also that of the catches, is made by means of bell-cranks worked by levers handled by the hammerman, who is placed upon a platform 4.800 meters above the ground. In this position he is not only sheltered from heat and sparks, but can both hear well the orders which are given him and see the signals which are made.

The piston is made of cast steel; the piston-rod is also of steel, and is secured to the piston by a nut, which is further secured by a ring sprung on hot. The piston is

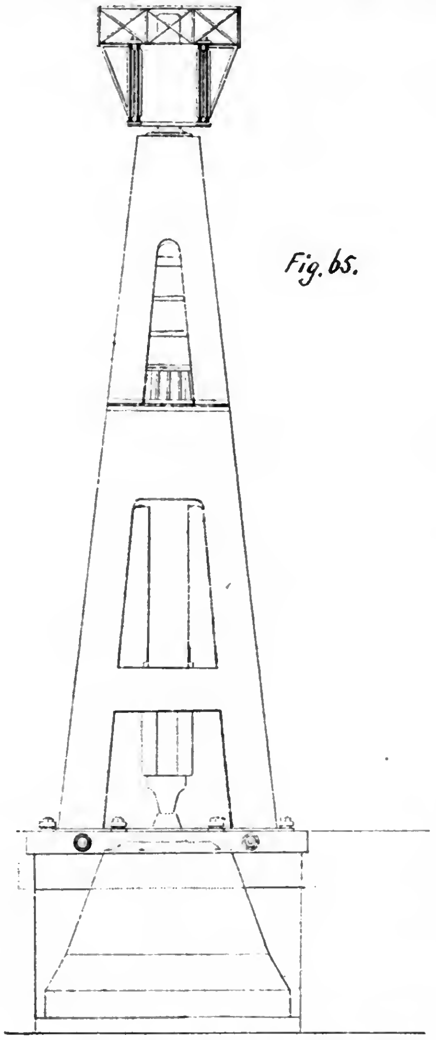


Fig. 65.

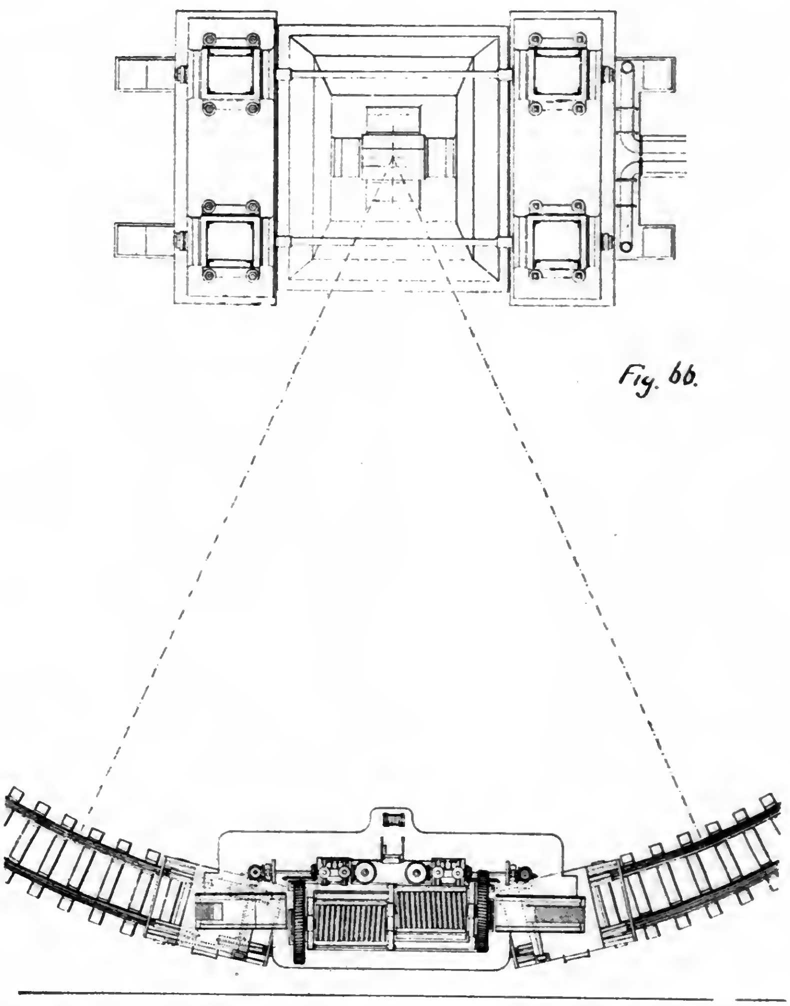


Fig. 66.

that ordinarily used, as it gives a very wide base, which secures complete stability and abundant space for handling heavy forgings. These legs are joined at a certain height by four plates forming braces, two of which serve to support the slides; they are prolonged around and above the cylinder and form a top or hood, serving to carry the cranes.

The clear distance between the legs is 8.000 meters, and the clear height under the braces is 3.400 meters. The total height from the ground to the pivots upon which the cranes rest is 19.600 meters.

The slides are made of two pieces of steel of a section shown in fig. 68, which are bolted on uprights made of plates and angles. The cross-section is widened in the middle, and a corresponding groove made in the side of the hammer-block works upon this portion. Very heavy catches or holding dogs are provided in order to support the hammer when it is necessary to make changes.

The cylinder is made in two parts, one above and one below, the latter serving also as a table or upper frame; this is supported by the frames and securely bolted upon fastened to the hammer-block by means of steel rings, the lower one being in a single piece, and the upper one in two pieces, held by heavy keys.

The weight of the moving parts—that is to say, the hammer, the die, the piston, and the rod—is 100 tons. The stroke of the piston is 5 meters, so that the work produced in the descent of the hammer will be 500 meter-tons. The diameter of the cylinder being 1.920 meters and that of the piston-rod 0.360, the exact section upon which the pressure operates to raise the hammer is 2.900 square meters. The pressure of the compressed air being 5.165 kilos. per square centimeter, the total lifting pressure will be 150 tons. If we assume a coefficient of 15 per cent. for the friction of the piston in the cylinder, the rod in the stuffing-box and the hammer in the slides, we see that this cylinder will have sufficient lifting force to move with all required speed, and that the weight of the striking mass could be even increased should it be necessary.

This hammer is served by two cranes, turning around its axis. These cranes are of the same type, and differ only in power, one lifting 100 tons and the other 150 tons.

The pivot to which they are attached is double, and is composed of two hollow pivots of unequal height, turning one inside the other upon a steel seat bolted securely to the summit of the hammer frame. These pivots are furnished with flanges, to which are secured by bolts square

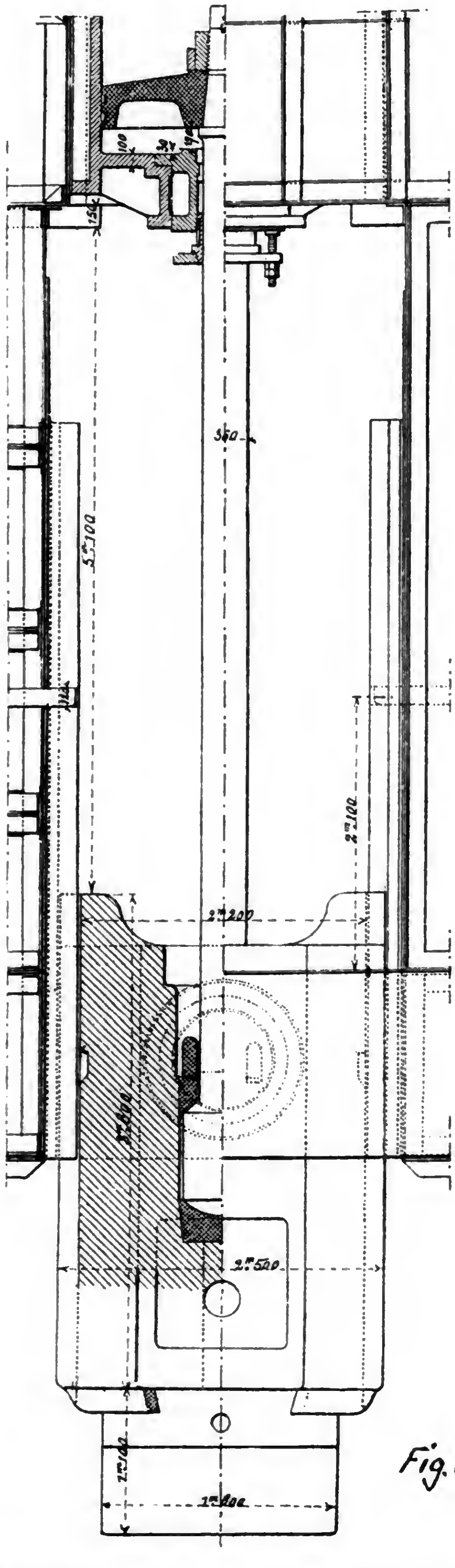


Fig. 67.

boxes made of wrought-iron plates and angles, to which are fastened the arms of the crane. These cranes are held at one end by this pivot fixed to the frame, but at the outer end are supported on separate upright posts resting upon trucks which move on a circular railroad track. The arms of the crane and the upright posts are made of plates and angles; the arms are 2.200 meters in depth and are 21 meters long.

On the upright posts which carry the outer end of the arms are placed the engines which work the cranes and which operate by compressed air. These give the following movements:

1. The motion of the large crane around the hammer.
2. The hoisting and lowering of the load.
3. The change of the load in a horizontal direction.
4. Movement of rotation of the load.

The last is made in the manner shown in fig. 69. The chain is led from the drum *T*, worked by the engine, on to a guide pulley *G*, and then passes from the two pulleys to the car *C*, and thence to the tackle *P*. The same arrangement is made for the second drum *T'*, driven by the second motor. The two tackles, *P* and *P'*, carry a chain which supports the ingot *L*.

When the two engines turn in the same direction, the two tackles are raised or lowered together, and therefore raise or lower the ingot; but if the two engines work in

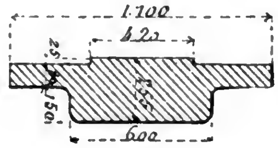


Fig. 68.

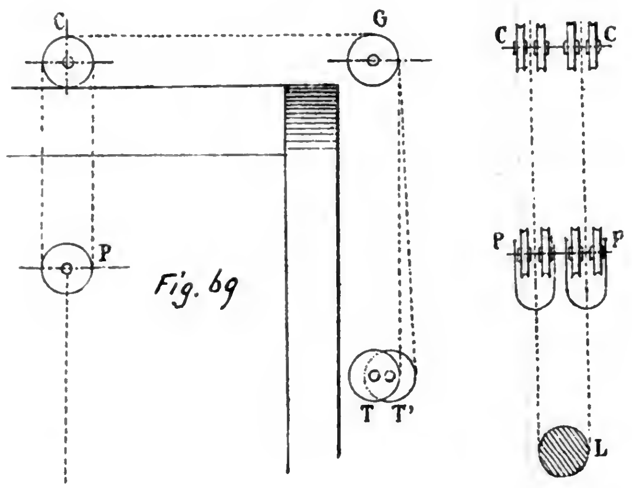


Fig. 69

opposite directions one of the tackles is raised and the other lowered with the same speed, and the friction of the chain upon the ingot gives the latter a rotary movement. This arrangement which deserves special notice for its simplicity, appears to give very good results.

Each hoisting wheel is moved by an engine with two cylinders of 0.200 meter diameter and 0.300 meter stroke, worked up to 200 revolutions per minute. These cranes have a total radius of movement of 21 meters.

The principal dimensions of this hammer are as follows:

Weight of working parts......	100	tons.
Maximum stroke of hammer...	5.000	meters.
Diameter of cylinder..........	1.920	meters.
Diameter of air-valve.........	0.340	meter.
Diameter of exhaust-valve.....	0.420	meter.
Width of the hammer.........	2.200	meters.
Clear space between the frames.	8.000	meters.
Clear height under the frames..	3.400	meters.
Height of the air cylinders.....	6.500	meters.
Height from the ground to the level of the crane pivot......	19.600	meters.
Height of the anvil-block......	5.500	meters.
Surface of the base of the block.	42.000	sq. meters.
Surface of the top of the block.	12.960	sq. meters.
Total weight of the anvil-block.	1,000	tons.

The air cylinder is made in two pieces, as already stated; the usual working pressure employed is 5 atmospheres.

CHAPTER XXII.

THE MARREL 100-TON HAMMER.

Experience having shown that the 100-ton hammer at Creusot and the 80-ton hammer of St. Chamond were very useful for the forging of steel ingots up to two meters in diameter, the firm of Marrel Brothers have decided to build, and have begun the construction of, a single-acting cannon of large caliber, shafts and cranks for large marine engines, and finally to manufacture steel armor-plates of great thickness.

The foundations of the hammer are placed on a rock, the surface of which has been dressed off perfectly level to receive a bed of cut-stone masonry, upon which is placed another bed of oak timbers strongly bolted together and intended to serve both as a support for the anvil-block,

Fig. 71.

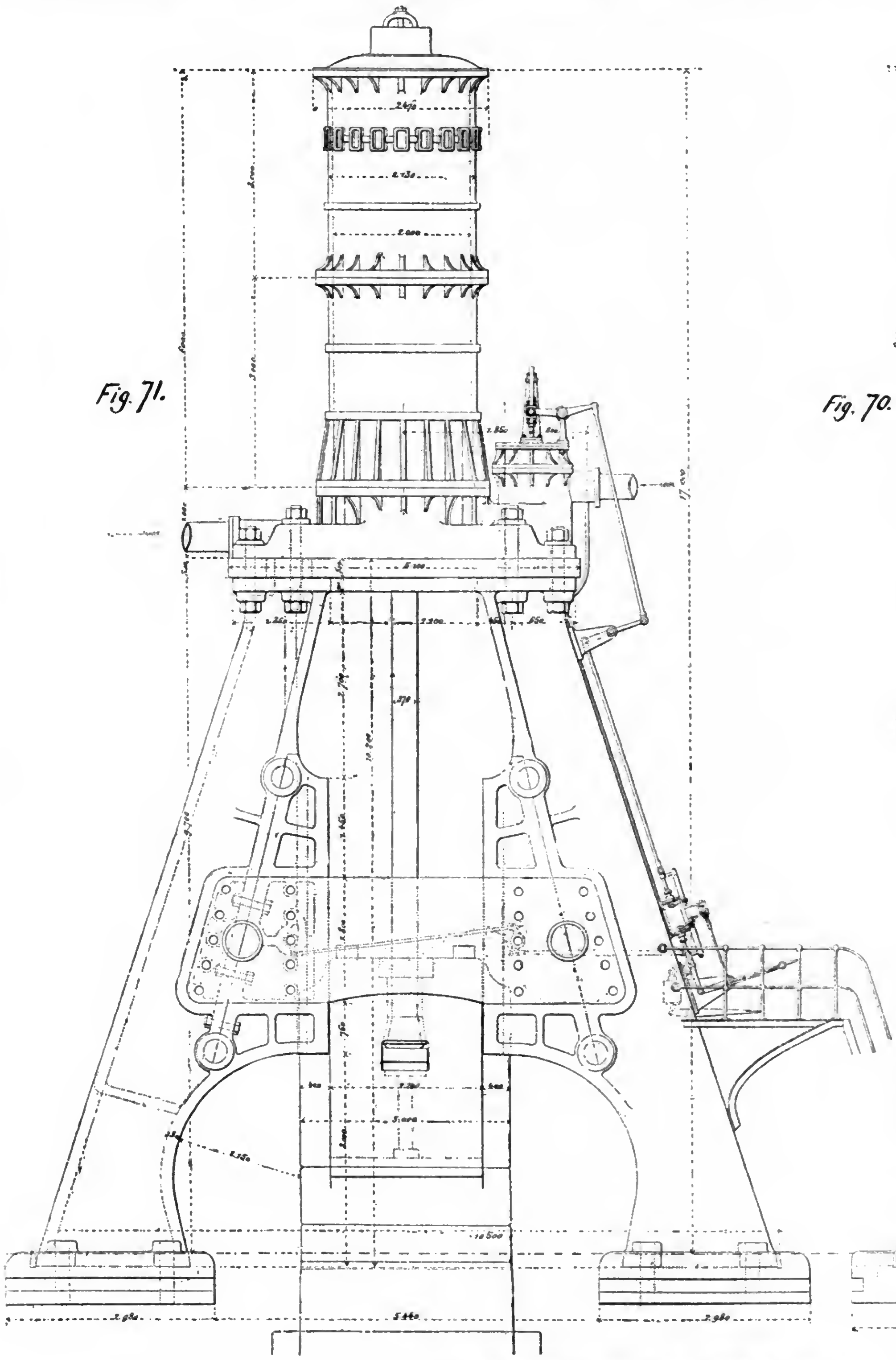
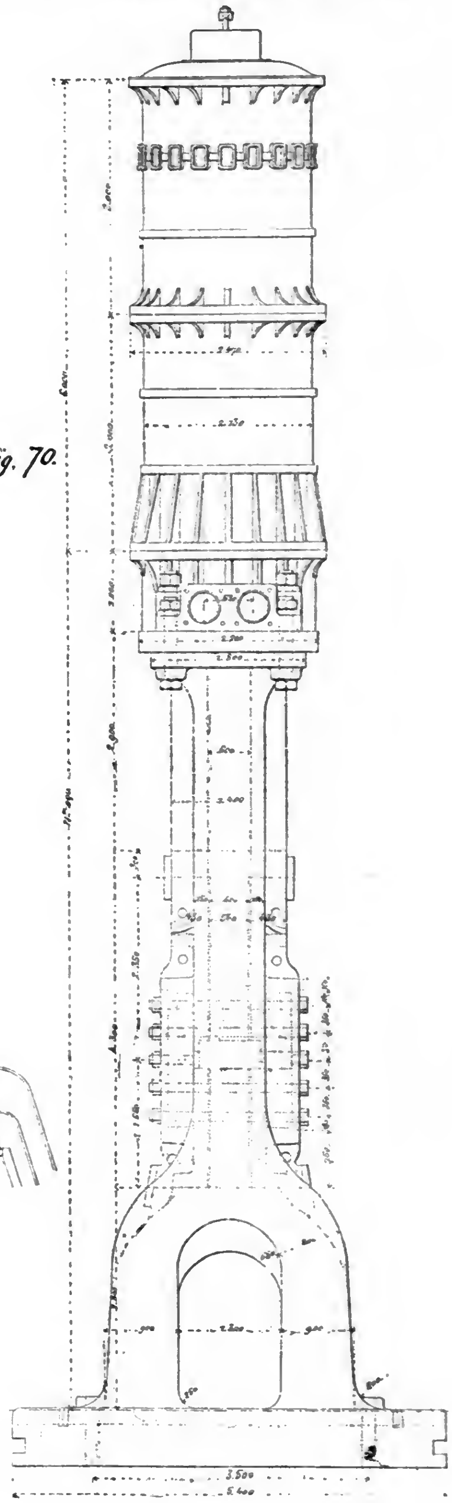


Fig. 70.



THE MARREL 100-TON HAMMER.

100-ton hammer, which will be placed in their Etaings forge at Rive-de-Gier.

This hammer is represented in the accompanying illustration, fig. 70 being a side elevation, fig. 71 a front elevation, fig. 72 a plan, figs. 73, 74 and 75 showing the construction of the foundation and the anvil. It is intended to forge heavy pieces of steel, such as tubes and hoops for which rests upon it, and as a spring to take up part of the shocks.

The anvil-block is composed of seven pieces arranged in four rows, the three lower ones being each in two parts joined together by rings or hoops put on hot; the upper piece, which receives the lower die, is in a single piece, its weight being 120 tons. The four rows are joined to-

gether by means of a number of keys, which make them in effect a solid block. The total weight of the anvil-block is 500 tons.

The frames are of cast iron. They rest upon seat-plates or shoes, also of cast iron, which are joined together by braces secured in grooves made in the shoes. These braces have a section of 160 square millimeters, and thus secure complete stiffness.

The frame proper, or legs, is of a single piece; the part carrying the slides is adjusted upon this and kept in place by heavy bolts and by rings put on hot over lugs cast for this purpose upon each part.

The legs are braced at about the middle of their height by two heavy plates 100 mm. wide, fitted perfectly, and fixed to the frame by a number of large bolts passing through the legs. They are joined above to the upper frame by bolts of 150 mm. In the interior of the legs there have been made two recesses in which are placed two

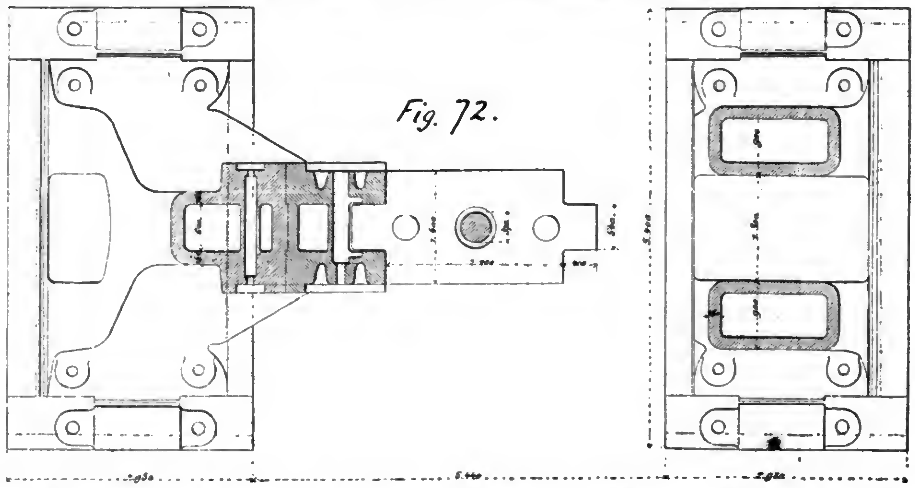


Fig. 72.

holding-catches or dogs, intended to support the hammer while the dies are changed. These are operated through intermediate bell-cranks by a foot-lever placed on the hammerman's stand.

For the upper frame or table, in order to reduce, as much as possible, the total height of the hammer, which is now 17 meters, MM. Marrel have used a plain plate of wrought iron 300 mm. in width, which certainly reduces the height very much; this plate is also much stronger than if it had been made of cast iron.

The cylinder is in three parts; the upper part carries at the top a number of rectangular holes, intended to allow the steam to escape in case the piston-rod should break. The lower part forms the steam-chest, and carries all the apparatus for the distribution of steam. The intermediate section is united by bolts to each of the two other parts. All of the parts have on the outside and near the flanges a series of ribs which strengthen them considerably and prevent breakage. The interior diameter of the cylinder is 2.000 meters. By using this large size the hammer will be able to work easily with a pressure as low as 3½ kilogrammes, the most unfavorable case which is likely to present itself.

Above the cylinder is a cover of wrought iron, having a manhole in the center, in order to permit the inspection of the interior of the cylinder and the piston without taking off the cover.

Steam reaches the hammer through a pipe 350 mm. in diameter, and the exhaust steam escapes through two others having the same total section and placed upon the same horizontal axis, in order to reduce, as we have noted above, the height of the hammer as much as possible. These two exhaust pipes are joined by an elbow, which then discharges into a pipe 500 mm. in diameter. The distribution of steam is made by a circular balanced valve 750 mm. in diameter. According to the formula which we have already given, this valve should be 850 mm.; therefore, in order not to modify the total area of the steam exhaust openings, the height has been increased, and for the same reason the stroke of the piston-valve has been also increased.

In practice, it is quite impossible for a man to work a piston of 750 mm. with a stroke relatively large. MM. Marrel have therefore conceived the excellent idea of using an independent steam cylinder to operate the valve. This small engine, which is of the Farcot & Duclos type, is placed beneath the hammerman's stand, and the lever which works it is placed close to his hand, so that only a slight effort is sufficient to start it. In this position it is constantly under his eye, and he can handle the valves very easily. The steam for this independent cylinder is taken from the main steam pipe by a small copper pipe, and its exhaust is carried through a similar pipe into the main exhaust pipe of the hammer cylinder.

The piston-rod, which has a diameter of 370 mm., is securely fastened into the piston, which is of cast steel, and which is furnished with four segments.

We should note here that, having considered the difficulty of transporting pieces of such great weight as those of this hammer, MM. Marrel have established in their forge a Martin steel furnace and also cupolas, so that all the pieces could be cast upon the spot.

The principal dimensions of this hammer are as follows:

Diameter of cylinder	2.000 meters.
Stroke of hammer	5.100 meters.
Width of the hammer between the slides	2.200 meters.
Total width of the hammer	3.000 meters.
Diameter of the piston-valve	0.750 meter.
Diameter of the main steam pipe	0.350 meter.
Diameter of the exhaust pipe	0.350 meter.
Weight of striking mass	100,000 kilos.
Weight of the hammer-block	72,000 kilos.
Weight of the piston and rod	16,100 kilos.
Weight of the die and fittings	10,000 kilos.
Weight of the cylinder complete	52,000 kilos.
Weight of the frame	230,000 kilos.
Weight of the shoes	128,000 kilos.
Weight of the anvil-block	500,000 kilos.

The total weight of this immense tool, including all the parts above the stone and wood foundation, is 1,068,500 kilogrammes.

(TO BE CONTINUED.)

MARITIME CANALS AND MODERN COMMERCE.

In a very interesting address made by Sir C. W. Wilson before the British Association at its recent meeting, he speaks as follows of the Suez and Panama Canals:

The opening of the Suez Canal, by changing the great commercial route, to the profit of the Mediterranean ports and to the injury of the Cape of Good Hope, has produced new changes in the relations between the East and the West, and England especially has felt the results. The changes referred to are three in number.

1. The raw materials and the manufactured products of the East arrive continually in greater quantity in the Mediterranean ports, going through the canal instead of, as formerly, to England to be distributed to other European countries. Odessa, Trieste, Venice, and Marseilles have

become centers of distribution for Southern and Central Europe, as Antwerp and Hamburg have for the North; the English merchants have lost the benefits which accrued to them from transporting and distributing the merchandise of the East in Europe. It is true that up to this time the transportation is still in great part in English hands, but should a war come this also would pass to other nations and would not easily be recovered. The industry of the Continent has been obliged, since the commencement of

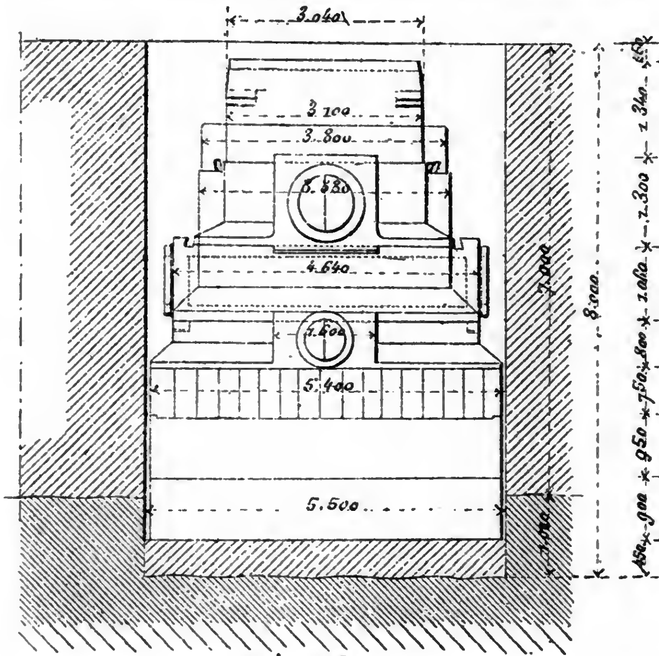


Fig. 73

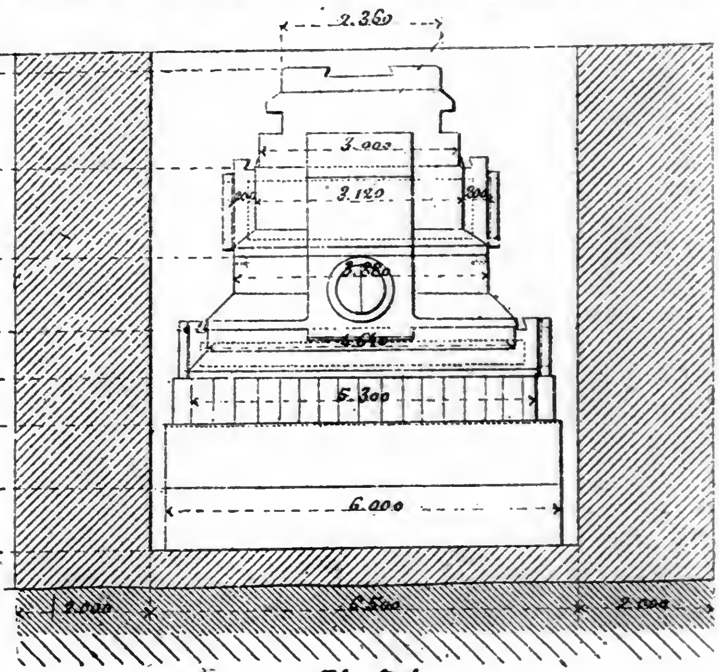


Fig. 74.

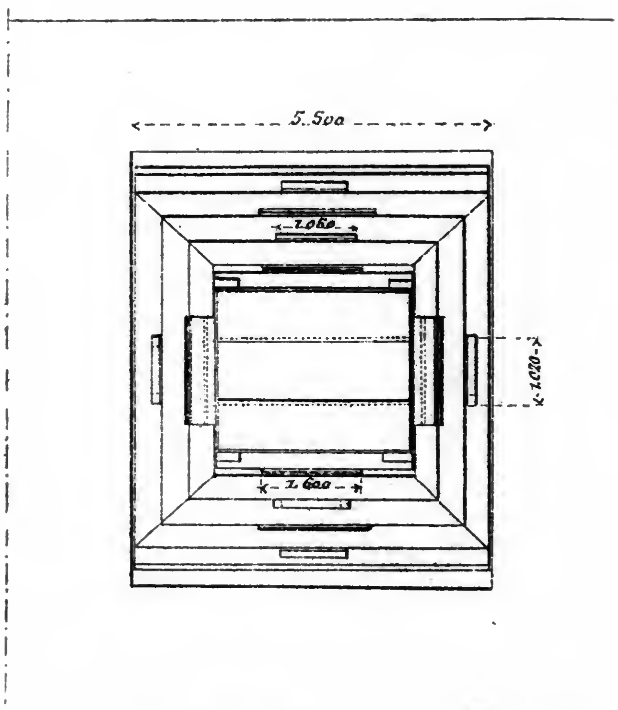


Fig. 75.

the present century, to support the position taken by England, and without doubt the control of the distribution of commerce which that country now holds will be lost sooner or later. The opening of the canal has hastened this time, to the injury of English manufactures and, in consequence, to the national wealth. England is gradually becoming less and less the warehouse of the world. It is feeling at present the working of that law under which a rearrangement of commercial centers must follow a change in commercial routes.

2. The abandonment of the route by the Cape of Good Hope has led to the construction of steamers especially designed for Indian and Eastern commerce through the canal. On this line coaling stations are numerous, and navigation, except in the Bay of Biscay, is much more easy than on almost any other long voyage; the result is that ships have been built of an inferior type from a point of view of size, speed, strength, and seaworthiness. These ships built for the canal route are altogether unfit for the long voyage around the Cape, and should the canal be closed by war or accident they would be useless for the transportation of Eastern traffic. Since the canal has been deepened ships have been slightly improved, but they are still unfit to undertake the Cape voyage. Without the canal English commerce would have been enriched by the ownership of a large number of fine steamers, which would form a fleet invaluable in time of war, and it would not be, as it is now, in perpetual terror of being paralyzed by the closing of the canal.

3. Sir William Hunter has well shown that since the opening of the canal India has appeared in the English market in competition with the English manufacturer, and the development of that colony as an exporting country, for both manufactured goods and food products, must necessarily bring about transformations in English trade and production which will not take place without causing suffering and serious loss.

The commerce of India has increased very rapidly; the exports have risen from £57,000,000, the average figure for five years previous to 1874, to £88,000,000 in 1884. Wheat, which was formerly one of the most insignificant of the exports, has become one of the principal objects of commerce, and since 1873 the export of Indian grain has risen from 100,000 to 1,000,000 tons. It is impossible to predict to what limits this commerce in grain will extend; it is one forerunner of the objects which India can put in competition with European production upon the markets of the world.

The situation forced upon England by the opening of the canal is in some respects like that of Venice after the discovery of the route by the Cape of Good Hope, but there is a wide difference in the way in which these events have been accepted. Venice did not attempt to employ the Cape route, but, on the contrary, made every effort to prevent other countries from using it; England by a natural instinct opposed from the beginning the cutting of the Isthmus of Suez, but was the first to profit by it when the canal was opened to commerce, and it has so far struggled with success against its rivals to retain the carrying trade of the East.

It is quite natural to ask, What will be the results of the opening of the Panama Canal? This canal, when completed as a ship canal without locks, will establish closer commercial relations between the eastern and western coasts of the American Continent, and will benefit merchants by diminishing the distance and the cost of insurance. It will also receive a part of the commerce between the East and the West, but it will not produce changes at all to be compared to those following the construction of the Suez Canal.

The present tendency in all maritime countries is that each should transport for itself the products of other countries which it needs. The problem of navigation has been practically solved by the construction of large steamers which go directly from one port to another without waiting or watching for winds or currents; the sole improvement to be expected in this direction would be an increase in speed, which may be brought up by improvements to 30 knots an hour. A further tendency is to shorten voyages by maritime canals and to build canals which will bring ocean vessels to the industrial centers of the interior and, in short, to utilize, wherever it is possible, water routes in preference to those by land.

In order to establish correctly the lines which these routes and these canals should follow, a profound knowledge of the surface and especially of the physical geography of the earth is necessary, and should form in our time the basis of the most serious study of commercial geography.

This study must not be limited to the mere knowledge of the places or the countries whose products may form the objects of commercial exchanges, or of the markets in which they can be sold most advantageously. The chief point is to discover, by the aid of history and science, the sources of the commerce of the future, the roads which it will follow and the points where its chief distributing centers will arise in obedience to its known and irrevocable laws.

A profound study of the geography and physical structure of the globe; of the local distribution of minerals, vegetable products and different forms of animal life, not forgetting man; of the influence of locality on man and animals; of the climatic condition of different regions—all this is essential in order to solve the problems which are now presented to us. A country which wishes to maintain or improve its commercial position and influence must study these questions, and must prepare its people to fight courageously in the approaching combat for the commercial supremacy of the world. This fight will be a severe one, and the victory will certainly remain with those who best understand and bring into practice the proverb that "knowledge is power."

I may add that from the earliest historic days it has been an immutable law of commerce that when a country can no longer transport its merchandise in time of war, the traffic which it has carried will pass to some other nation. England is now the great carrying country of the world; when it can no longer defend its commerce it will share the fate of Venice, Spain, Portugal and Holland.

QUADRUPLE-EXPANSION MARINE ENGINES.

THE accompanying illustration, taken from *Industries*, represents the engines of the steamship *Buenos Ayres*, built by Denny Brothers, of Dumbarton, Scotland. These engines, of which there is an exquisite model at the Glasgow International Exhibition, are on the quadruple expansion tandem principle, patented by Mr. Walter Brock, Dumbarton, and the model is the work of Mr. David Carlaw, Glasgow. The four cylinders of the engines are 39 in., 46½ in., 64½ in., and 92 in. in diameter respectively, having a stroke of 5 ft. The cylinders are so arranged that the bottom of the high pressure cylinder forms the cover for the cylinder below, and the bottom of the third cylinder forms the cover for the low pressure cylinder, the whole being so constructed that the upper and lower cylinders can be removed at any time without disconnecting the valve-gear or breaking any connections except those between the cylinders. The two lower cylinders are bolted together, the space between them acting as a receiver for the exhaust from the second cylinder. The advantage of this design is its applicability to the conversion of ordinary two-cylinder compound engines into quadruple expansion. The piston rods have metallic packing, where they pass the bottom covers of the high pressure and third cylinders. There is one piston valve for the high-pressure cylinder, and one double ported slide valve for the second cylinder. For the third cylinder there are two piston valves on separate spindles, and two double ported slide valves for the low pressure cylinder. Both piston and slide valves for each pair of cylinders are actuated by the same valve motion. Doors are arranged on both sides, so that the valves can be examined without breaking the casing joints, the doors being large enough to allow the valves to be drawn out sideways. The valves are actuated by the ordinary link motion, one spindle being used for the first pair of valves and two spindles for the second pair. The latter pair is connected by a stiff cross-head below the stuffing-boxes. The pistons are of cast steel, all of a single thickness, and are made cone-shaped. Messrs. Brown Brothers constructed the steam and hydraulic starting gear, to which hand reversing gear is attached.

There are two single-acting vertical air pumps, 26 in. diameter and 2 ft. stroke, and two double-acting vertical circulating pumps 14½ in. diameter and 2 ft. stroke, worked by links and levers from the main cross-heads. There are also two feed and two bilge pumps, the former with brass and the latter with cast-iron plungers 5½ in. diameter and 2 ft. stroke. There is also a steward's pump 6 in. diameter and 12 in. stroke on the back of the condenser driven by the pump lever. The working pressure of these engines is 180 lbs. per square inch. This type of engine has only been manufactured for about two years; but during that period as many as 14 entirely new engines have been finished or are on order, and about four or five old engines have been converted to the new principle.

UNITED STATES NAVAL PROGRESS.

NEW ships for the Navy need new guns; and while the Department has been busy building the ships, the guns have not been neglected. Provision has been made for the purchase of forgings and the assembling and finishing of the guns; also for the establishment of the necessary plant at the Washington Navy Yard.

The following clear and interesting account of some of the work that has been done in this direction is taken from the latest issue of *Naval Intelligence*, the official publication of the Department:

STEEL-CAST GUNS.

By the act of Congress approved March 3, 1887, the sum of $20,400 was appropriated for the purchase and completion of three rough-bored and turned steel-cast 6-in. guns, one to be of Bessemer, one of open-hearth, and one of crucible steel. In response to the Department's advertisement the Pittsburgh Steel-Casting Company bid for the Bessemer casting, and the Standard Steel-Casting Company, of Thurlow, Pa., for the open-hearth casting, and contracts were subsequently awarded to these two companies.

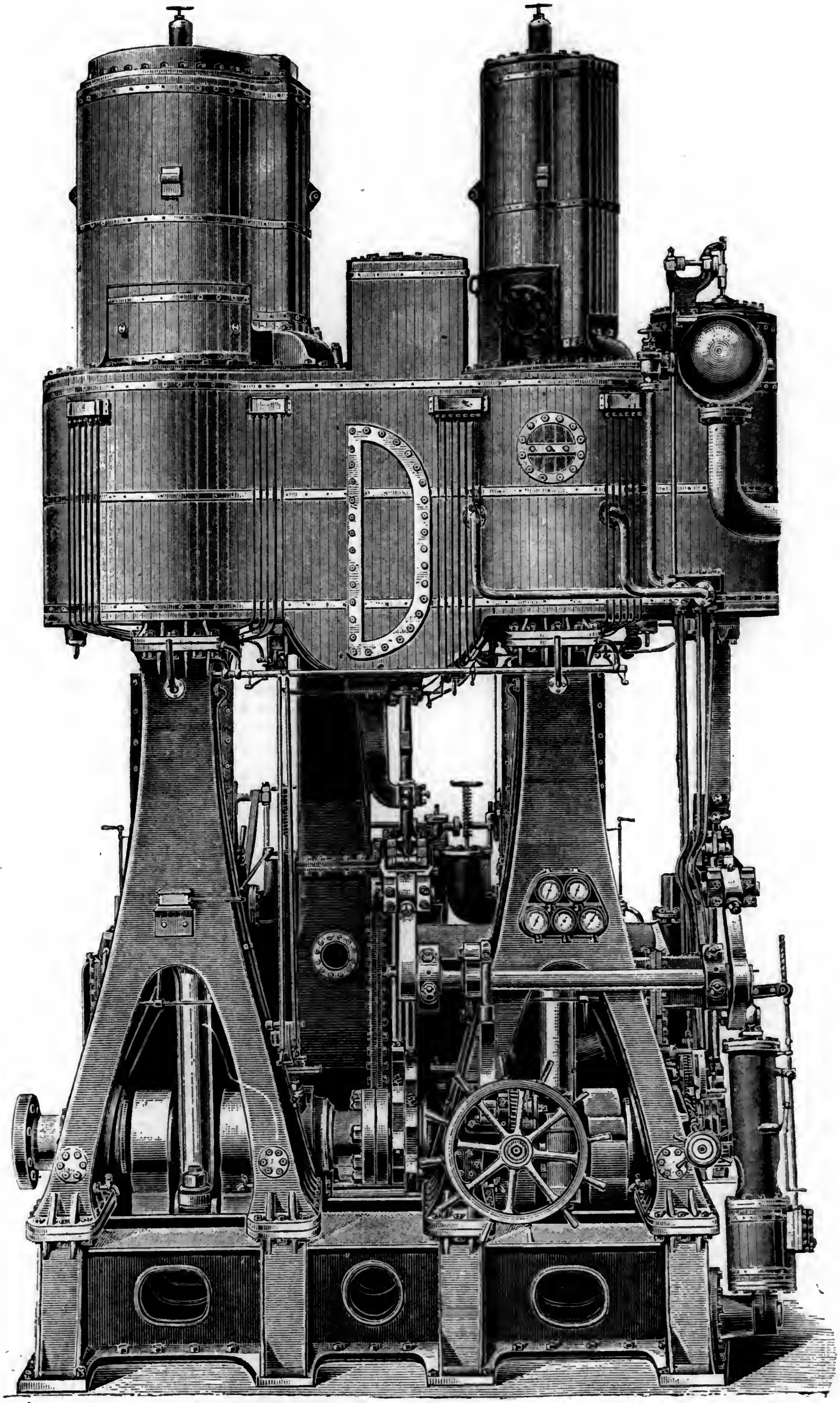
No proposals were received for the gun of crucible steel.

The chief requirements of the specifications are as follows:

"The castings from which these guns are to be made must be composed of steel of domestic manufacture, made from the best quality throughout the mass, and free from slag, seams, cracks, cavities, flaws, blow-holes, unsoundness, foreign substances, and all other defects affecting their resistance and value.

"The guns are to be each of one piece, except the breech-plug (and the trunnion-band, if so desired). They must be unforged.

"The Department is to have the right to satisfy itself



QUADRUPLE-EXPANSION MARINE ENGINE.

BUILT BY DENNY BROTHERS, DUMBARTON, SCOTLAND.

(by inspection) that the gun is actually made of the kind of steel mentioned in the proposal.

"The bidder must state in his proposal the minimum physical characteristics that he engages his metal shall possess, this information being necessary to an intelligent choice between proposals for the same kind of gun. To this end he must insert in the proper columns of the table in the 'proposals' sent herewith, the minimum tensile strength, elastic limit, percentage of elongation, and contraction of area that he engages to have exhibited by the test specimens when taken, as hereinafter provided."

The characteristics stated in the proposals are as follows :

	Pittsburgh Steel-Casting Co.	Standard Steel-Casting Co.
Stress to be borne at elastic limit .... pounds	40,000	40,000
Stress to be borne at tensile limit ....pounds	80,000	80,000
Per cent. of elongation to be shown.......	7	10
Per cent. of reduction of area to be shown........ .	7	10
Weight, finished ....pounds	11,000	12,000

"The tensile strength and elastic limit of the steel will be reckoned on the original cross-section of the specimen (0.1963 of a square inch). The elongation and contraction of area will each be measured after fracture. The former will be expressed in per cent. of the original length between measuring points, and the latter in per cent. of the original cross-section.

"The test-specimen bars are to be taken from the casting after final treatment (at the expense of the contractor), and must be cut within the finished section prolonged, and as near to the finished gun as practicable (these points being verified by inspection).

"Rough-bored and turned castings that pass inspection shall be machine-finished by the Department within four months after delivery by the contractor. The statutory test shall take place within three months after completion as above.

"Payment will be made when the statutory test of the gun is successfully completed. This test is to consist of ten rounds (the weight of the projectile and muzzle velocity being at least 100 pounds and 2,000 ft., seconds, respectively), fired as rapidly as the gun can be loaded by hand and discharged. A critical inspection will be made after the test, and the piece must not exhibit any defects or weakness."

The contract price of the Pittsburgh casting is $3,300 ; that of the Thurlow casting is $5,300.

The following are the results of the physical tests made at the Washington yard :

SPECIMEN.	Tensile Strength per Square Inch.	Elastic Limit per Square Inch.	Elongation after Fracture.	Reduction of Area after Fracture.
PITTSBURGH GUN.	Pounds.	Pounds.	Per cent.	Per cent.
Muzzle :				
Longitudinal............ ...	81,185	40,464	18	21.26
Transverse.....	80,722	43,035	18.25	20.79
"	79,174	40,979	15.55	18.75
Breech :				
Longitudinal......	88,973	51,693	9.15	10.80
"	89,686	51,693	10.35	13 88
Transverse...................	75,527	51,693	2.65	2.79
"	73,847	59,332	.60	1.60
"	73 236	55,258	1.85	4.35
THURLOW GUN.				
Muzzle :				
Longitudinal.	80,468	37,942	20.60	23.26
Transverse...	80,570	38,961	18.20	30.12
"	81.334	38,451	18.50	27.40
Breech :				
Longitudinal.....	80,519	38,961	19.55	24.31
"	80,977	38,451	19.10	27.40
Transverse.............. ..	80,162	37,942	20.65	22.56
"	79,246	36,414	24.75	32.43
"	79,309	37,072	27.85	40 78

The deficiencies in the case of the Pittsburgh casting are marked, but they have been waived, and the piece has been provisionally accepted. Both castings have been forwarded to Washington to undergo machine finishing.

The interior dimensions of the finished guns will be the same as those of the 6-in., Mark II.

GUN FORGINGS.

Contracts have been concluded for the manufacture by the Midvale Steel Company of 32 sets of steel forgings for 6-in. guns, and one set of chase-hoops for a 10-in. gun. All deliveries are to be completed by March 2, 1889.

The specifications for tests and acceptance are substantially, and the physical property limits are exactly, the same as those published in last year's number.

Twenty-two sets of the 6-in. forgings are intended for guns of a new design to be known as Mark III. The chase-hoops of the new gun extend all the way to the muzzle. The diameter of the chamber is reduced to 7 in., and the length is correspondingly increased so as to preserve the capacity of Mark II. The length over all is 196 in. ; weight of gun, 11,000 lbs. ; thickness of wall over chamber, 6.75 in. ; at muzzle, 2.40 in.

OVERHEAD TRAVELING CRANES AND SUPPORTS FOR SAME.

Contracts have been made with the Morgan Engineering Company for the construction and erection at the Washington Navy Yard, of one 25-ton, one 40-ton, and one 110-ton overhead traveling crane ; the first-named to be ready for delivery, complete in all respects, by September 20, 1888 ; the second, by October 6, 1888 ; the third, by March 6, 1889.

A separate contract has been made for the construction and finishing of the iron frame for a 12-in. gun-shop and supports for the 110-ton crane within the same ; all to be ready for delivery, complete in all respects, within 90 days from May 1, 1888. The same contract provides for the erection of supports for the 40-ton cranes.

GUN LATHES.

The Department has called for proposals for furnishing the necessary material and labor for the construction, delivery, and erection at the Washington Navy Yard, of eleven 6-in. gun lathes and one slotter.

Also, the same for the construction, delivery, and erection of sixteen 16-in. gun lathes.

PROPOSED MONITOR TURRET MOUNT.

The Pneumatic Gun Carriage & Power Company having proposed to install a pneumatic plant on one of the monitors, the proposition was referred to the Pneumatic Gun Carriage Board, the Board being authorized to confer with representatives of the Company upon certain terms that were not deemed satisfactory. The conference led to certain modifications of the original proposals, and, ultimately, to a contract, signed April 25, of which the following are the leading features :

The company to supply, and set up on board the monitor *Terror*, at Boston, Mass., for the sum of $228,750 : (1) All the pneumatic machinery, gearing, air compressors, etc., necessary for steering the ship and revolving the turrets ; (2) four 10-in. gun carriages, each to be provided with pneumatic elevating cylinders, pneumatic ammunition hoists and loading apparatus, etc. ; (3) a complete pneumatic refrigerating apparatus. All of the above to be ready for installation within 18 months from the date of contract, and to be ready for test within six months from the time thereafter that the vessel is delivered to the contractors in condition to receive it.

On completion, the plant to stand the following test : (1) The helm to be shifted from hard-a-starboard to hard-a-port (or the reverse) in 16 seconds, and as often as once a minute ; (2) both turrets to be turned at the same time and at the rate of one complete revolution in two minutes, the turrets to be at all times under complete control in accordance with the requirements of an efficient manœuvring of the guns ; (3) the ammunition to be supplied, and the guns to be sponged and loaded with sufficient rapidity to fire five service rounds from each gun (20 rounds in all), in volleys of four shots, at intervals of not more than three minutes between consecutive volleys. The system is to perform the above operations simultaneously. The initial

air pressure in the reservoirs is to be not greater than that which they are designed normally to carry, and the terminal pressure must be great enough to carry on efficiently the work of steering, revolving the turrets, and manœuvring the guns.

PETROLEUM FUEL.

(Paper read before the National Electric Light Association by S. S. Leonard, of Minneapolis.)

PETROLEUM has been used as a fuel for a number of years. Experiments to determine its practicability as a fuel have been creating a great deal of attention from those interested in the matter for the last 20 years, and it is now occupying the minds of some of our ablest engineers and inventors. The successful use of oil as a fuel has, however, been of very recent date, yet so rapidly has it grown in favor that to-day it is regarded as a strong competitor of coal for steam-generating purposes or where heat and fire are wanted. It was with a great many knowing winks and nods of the head from the engineers and firemen, who laughed at the idea of making steam by the use of oil, that the writer attempted the use of petroleum as a fuel. Of course it would not work, and it did not work. Why? Because those who were using it did not want it to, as they were afraid some one would lose his job. We had seen enough of its workings to satisfy ourselves that it could be made a success, and the result is that to-day we are saving from 20 to 25 per cent. on the cost of the fuel, and 50 per cent. in labor, and these same men who laughed so hard on the start at our attempt to use oil would feel that this world was a poor place to live in were we to return to the use of coal, for not only their hearts but their backs would certainly be broken.

Its advantages over other fuels are many. In the first place, it is much easier handled; a steadier fire is easily maintained under your boilers, consequently the steam is kept at a more even pressure—a very important thing in the running of electric lights; there is no opening of furnace doors, allowing cold air to come in contact with the boilers, and there are no impurities in the oil such as abound in coal. When through with it, by a simple turn of the wrist your fire is put out, and your ash-pits are as clean as they were before the fire was started. In less time than it takes to tell it you can start the fire. It is only rivaled in handling by natural gas, and even then, unless we have all the modern appliances for the handling of this gas, it is far easier to manipulate.

Permit me to describe the arrangements for the handling and use of this oil put in under the supervision of the writer. The oil is received in tank cars holding from 90 to 150 barrels each (42 gals. to a bbl.). From these cars it is drawn off through a valve in the bottom of the car to a storage tank or tanks, there being two of them, holding about 320 bbls. each. These are placed underground, so that the oil runs from the car into them by gravity; care should be taken not to spill the oil or stir it up more than is necessary, as the odor from it is fully equal in strength to that of new-mown hay, if not quite as agreeable. To prevent the stirring up of the oil, the supply pipes entering through the top of the tanks run nearly to the bottom, so that the tanks are practically filled from the bottom. In the top of each tank are manholes and a vent pipe; this latter is extended above the tanks a short distance. These tanks, which are boiler-shaped, are placed end to end, with a space of about 8 ft. between them. This gives room to get at the various pipes. They are joined together at the bottom by a pipe, which also connects with the supply pipe running to the boiler-room. Then in the bottom of each is a drain pipe which will admit of cleaning them out whenever necessary. There is also a gauge glass in the end of each to show how much, if any, water is in them; there is also a gauge made by a copper float, which indicates the amount of oil in each tank. In cold weather a small steam coil is inserted in the tank car around the mouth of the valve to heat the oil, so that it will flow readily, for when the thermometer gets in the vicinity of 30 or 40 below, the oil is apt to be a little thick. Care should be taken not to heat the oil too much, for when hot it generates considerable gas, which is not only very odorous, but is really the cream of the fuel. I think it an advantage to have the storage tanks underground, there being less danger from them in case of fire, and during the winter the oil is less likely to chill. An open light should never be used near them; although the oil itself is really hard to ignite unless heated to a certain degree, still there is apt to be more or less gas around, which is quite explosive if brought in contact with fire. The supply pipes to the furnaces are provided with a valve where they enter each tank, also one in the fire-room. This pipe, a 2½-in. one, is enlarged to a 6-in. for about 4 ft., and in this 6-in. pipe a small steam pipe is inserted. With this the oil is heated from 130 to 140 degrees. This lightens it so that it burns more readily, or, I should say, is turned into gas.

We now come to the burners, which are also fed by gravity, as the storage tanks, although underground, are still higher than the furnaces. One might suppose that, owing to the recent introduction of petroleum as a fuel, some difficulty might be experienced in obtaining a burner, but their name is legion; and they are as numerous as electric light systems, and like them in another respect—each man's is the best. Our experience has been that the more simple the burner the better the result. One that thoroughly vaporizes the oil before burning it is, we think, preferable to one that burns the oil. In the former there can possibly be no waste. In furnaces where we have been using this kind of a burner the bricks are as clean as they were the day they were put in. Steam and hot air are the other ingredients that are used in connection with the oil, and an abundant supply of the latter we have found adds very much to the efficiency of the fire.

Regarding the proper settings, circumstances will determine that to a certain extent. An excellent plan is given by the Standard Oil Company in their pamphlet, "Oil as a Fuel." This we have adopted with a few modifications which we found necessary by experience. There is no doubt that a hotter fire can be obtained from oil than from coal or wood, and when the oil is properly used the smoke nuisance is solved which has been agitating the minds of the people of some of our large cities, for there is not a particle of smoke to be seen issuing from the stack, not even when everything is running full blast.

A word as to its danger: When properly put in and handled with ordinary care, or when good common-sense is used in the employment of this oil, I do not see why it should be any more apt to cause trouble than coal, although the insurance companies insist on higher rates when used. I think it more from ignorance of the subject than from there being any more danger. At the same time I am willing to admit that it could be put in and used in such a way as to greatly increase the danger of fire. So might your house be wired for electric lights, piped for gas, or a kerosene lamp hung on your gasolene stove filled in such a manner that the fire risk is much greater than with your neighbor, who uses electric lights, gas, kerosene or gasolene the same as you do, but has his put in properly and handles it as it should be handled. As to its economy over coal, I have already mentioned that there was a saving of from 20 to 25 per cent. on the cost of fuel, and from 40 to 50 per cent. in labor. From tests recently made by us, the following figures were obtained: 111.34 H. P., running six hours, used 250 gals. of oil, costing \$5.50, or at the rate of 70 cents per 100 H. P. per hour; 104.8 H. P., running six hours, used 3,461 lbs. of coal, costing \$5.45, or at the rate of 86 cents per 100 H. P. per hour. Another test gave the following figures: 96.45 H. P., running eight hours, used 4,014.75 lbs. of coal, costing \$6.32, or 80 cents per 100 H. P. per hour; 115.54 H. P., running seven hours, used 233 gals. of oil, costing \$5.05, or 62 cents per 100 H. P. per hour. On the above figures, oil is from 17 to 32 per cent. cheaper than coal. The highest evaporation made with oil was 14.8 lbs. of water per lb. of oil, with feed water at 103, and with coal 5.38 lbs. of water per lb. of coal, feed water at 103. The coal used was a good grade of Illinois lump, costing \$3.15 per ton, but which is usually worth \$3.25.

In the matter of labor one man can easily attend from seven to ten 150-H. P. boilers, and then have less to do than he would were he firing one boiler with coal. After

a week's run with oil; your boiler flues are much cleaner than they would be from the use of bituminous coal for one night, especially Western coal. Your fire-room can be kept as clean as your dynamo-room. There being no ashes you are saved the expense of handling them as well as the dirt, and the former is no small matter where some 20 tons of coal are being used every 24 hours. I might say that the above tests were made during a part of the day's run, and it is our opinion that a more favorable showing could be made with the oil where a larger number of boilers are in use. It seems to work better with a good fire than where a small fire is sufficient.

ELECTRIC SUBWAYS IN NEW YORK.

(Paper read before the National Telephone Exchange by L. F. Beckwith.)

In the following statement I have recorded a few data relating to the construction of electrical subways in the city of New York which may be of interest. The work was commenced in the latter part of 1886, and has been carried on since, with but slight interruption each year during the season favorable to out-of-door operations. The subways as laid out and built have been authorized and approved from time to time by the Board of Electrical Control, and the Consolidated Telegraph & Electrical Subway Company has been directed by the Board to construct them under its contract with the latter. The execution of the work has been intrusted by the above company to its sub-contractor, the Phœnix Construction Company, which has charge of all subway construction in this city.

The subways have been designed and laid out to meet the main requirements of the chief connecting or trunk lines of the various electrical companies so far as they could be ascertained, and so far as they could be conveniently grouped together. The principle of keeping the high tension electric currents for arc lighting and power in subways on one side of each street, and the low tension electric currents for telephone, telegraph, and other purposes in subways on the opposite side of the street, has been laid down and so far adhered to. The question of distribution from the conduits has been wisely left by the Board of Electrical Control to the various electrical companies to express their preference for the method best suited to their special systems. This the companies have been repeatedly invited to do, and while some have responded, and their methods of distribution having been approved as reasonable and feasible, they have been accommodated as rapidly as possible; other companies have held aloof and refrained from action, apparently wasting precious time and neglecting to occupy and secure their commercial field and districts.

The subways built, except the Edison, are all on the "drawing in" system, which provides a group of tubes or ducts extending from one manhole to another, admitting of the drawing in and out of the electrical cables, and affording convenient access from the street. Different systems of grouping the ducts in the trench, and different materials have been employed, consideration being held of the importance of the line, the question of cost, the durability, tightness against water and gas, etc. Experience has shown us that a main conduit consisting of separate pipes which can be crowded or curved or kept apart is the best adapted to overcome the numerous obstructions met with underground, and frequently diminishes the trenching necessary. Screw-jointed, asphalted wrought-iron pipe laid preferably in hydraulic cement concrete present the greatest tightness of duct against gas and water, united with the greatest strength. The cement pipe and creosoted wood tubes present also features of great merit and adaptability. A special feature of New York subway difficulties is the steam-heating underground system, of which the leaks in certain localities greatly interfere with the ducts and cables, precluding the use in such places of materials of construction softening or melting at about 160° to 200° F. In the case of long telephone lines, the desirability of comparing non-metallic and metallic ducts in respect to their influence on low tension currents has also been kept in view. A continuous line of telephone and telegraph subway is now completed about seven miles long, and the above comparison can be made on five to six miles of this length.

The endeavor has been to provide a subway construction that will be most durable, and that will give the best mechanical protection to the cables against injury from settlement of the ground, heat, water, gases, etc. The solution of the electrical question of underground working is one that relates to the manufacture of suitably insulated cables, and belongs properly within the province of the electrical companies.

The work accomplished up to September, 1888, is shown in the accompanying table:

Dorsett ducts, coal tar concrete	235,837	ft.
Zinc tubes laid in hydraulic cement concrete	68,883	"
Creosoted wood tubes	167,175	"
Cement pipe laid in hydraulic cement concrete	216,626	"
Iron pipe laid in asphaltic concrete	131,284	"
Iron pipe laid in hydraulic cement concrete	1,423,722	"
Iron distributing pipe	23,301	"
Edison iron tubes	222,794	"
Grand total length of single ducts	2,489,622	ft.
Grand total length of single ducts	472	miles.
Grand total length of trenches	37	"
Number of manholes	523	
Total length of telephone and telegraph ducts	376	miles.
Total length of electric light ducts	96	"
Length of telephone and telegraph trenches	19½	"
Length of special electric light trenches	17½	"

Besides the above there is still about three-quarters of a million feet of single duct for telephone, telegraph, and electric light purposes, authorized by the Board of Electrical Control to be built, that remains to be constructed, besides contemplated lines.

The standard size adopted for telephone ducts is 2½ in. clear inside diameter, corresponding to a capacity of 100 wires, or 50 conductors in metallic circuit grouped in a lead-covered cable. The chief portion of electric light ducts other than Edison ducts are 3 in. clear inside diameter. The manholes are all of brick laid in cement mortar with 8 to 12-in. walls and concrete bottoms. They vary greatly in form, and are from 8 × 12 ft. to 4 × 4 ft. 6 in. in size, and from 6 to 12 ft. deep. The street casting used has a double cover; the inner cover and rubber gasket are held down by a wrought-iron cross-bar, a bolt and padlock. The covers are practically tight against water.

The systems of distribution in use are as follows: For telegraph purposes, an iron pipe from the manhole connects underground with a building or with the foot of a pole. For telephone purposes the above method is used, and also in connection therewith a pipe running up the face of the building to the roof, where, from a fixture, the cable is divided for distribution on the block and surrounding blocks. Sometimes the pipe is carried up through an elevator or ventilating shaft. In addition to the above, in the down-town districts, and along Broadway to Union Square, an iron 3-in. pipe is laid in the trench above the subway, and provided at intervals of about 50 ft. with malleable iron circular distributing or service boxes with screw covers 12 in. in diameter, with side outlets through which a cable can be conducted by a service-pipe into the buildings.

For electric light distribution the Edison Company have their special system laid. The Johnstone cast-iron distributing conduit, with six ducts and flush boxes, has been authorized to be laid in Broadway, from 14th Street to 35th Street, for purposes of electric light distribution, and will provide all the necessary facilities for this district.

Up to August 27, 1888, there were 3,567 miles of wire laid in the subways by the Metropolitan Telephone & Telegraph Company. This company has laid a 100-wire lead-covered Patterson cable from Whitehall Street to 58th Street, a distance of about six miles. This cable is believed to be the longest of this size in existence underground. The Western Union Company has about 100 miles of wire underground, and the Edison Company about 126 miles. The Brush Electric Illuminating Company is putting an 8-conductor Standard cable in the Broadway conduit from 14th Street to 35th Street, a distance of one mile, making eight miles of electric arc-light wire. Other applications for space in the subways and for the construction of additional electric light lines are pending.

CATECHISM OF THE LOCOMOTIVE.

(Revised and enlarged.)

BY M. N. FORNEY.

(*Continued from page 473.*)

CHAPTER XVI.—(*Continued.*)

THE RUNNING GEAR.

QUESTION 480. *Why are the ends g′, g′ of the springs attached to the lever* A A?*

Answer. Because if there is a spring for every axle and the hangers are fastened to the frames, then evidently the locomotive has as many points of support as it has axle-boxes. Every shock from the rails is transferred through the wheel and the axle to the nearest axle-box and the spring belonging to it, and the latter must be made strong enough to receive and dispose of the whole of it. If the adjacent hangers, *g′*, *g′*, fig. 286, of the adjoining springs, *B* and *B′*, are connected by an equalizing lever, *A A*, which turns on the fixed point *C*, then the shock which affects one wheel will be transferred first to the corresponding spring. From this spring a part of the shock will be transferred to the frame by the hanger *g*, and a part by the hanger *g′* to the equalizer, which will transfer the pressure to the adjoining spring *B′*. If by some unevenness of the road or a powerful oscillation of the locomotive a spring is momentarily burdened, the equalizer thus causes the next wheel to receive part of this load.

The advantages of this arrangement are evident: since the springs have to receive only a part of the shocks, they can be made less strong and therefore more flexible. The danger of running off the track and that of breaking axles, springs, and hangers, is therefore reduced by the use of equalizing levers.

QUESTION 481. *How are the equalizing levers constructed?*

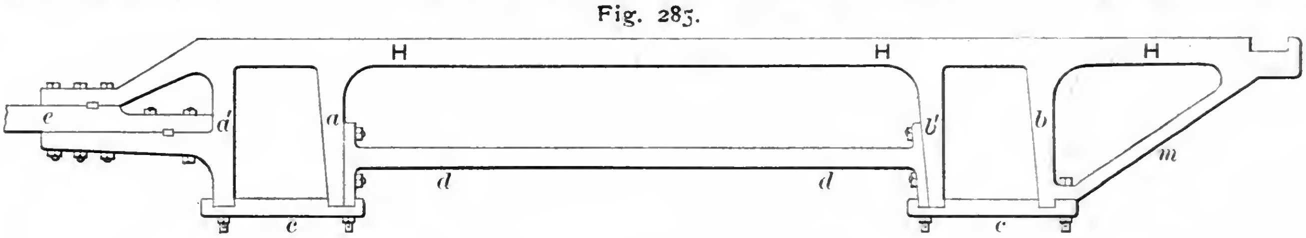
Answer. They are made of wrought iron and are supported in the center by a fulcrum, *C*, fig. 286, which is fastened to the frame or boiler or both. The spring-hangers *g′*, *g′* are usually attached to the levers by eyes and keys. Sometimes eyes are made in the lever, as shown in fig. 286, and the hanger is inserted into the eye and held either with a key, as shown, or else with projections which are forged on the hanger below the lever. In other cases the hangers are made with an eye which embraces the end of the lever.

QUESTION 482. *How is the distribution of weight of the engine affected by the equalizing levers?*

Answer. The effect of the equalizing levers is to distribute the weight equally on all the driving-wheels. This is apparent if it is observed that the weight suspended from each of the spring-hangers of each spring in fig. 286 must be the same; for if the weights in the two hangers *g′* and *g′* were unequal, then the end of the spring which supports the heaviest weight would be drawn down until the pressure was equalized. If the weights suspended from the two hangers *g′* and *g′* attached to the equalizing lever were unequal, then the one supporting the greatest load would draw up its end of the equalizer until the weights were again in equilibrium.

Another effect of the equalizing levers is that each side of the locomotive is supported in such a way that the action is the same as it would be if it was supported on one point. If, for example, we have a heavy beam, say a piece of timber like that shown by *A B*, fig. 302, suspended at one point, *C*, in its center, to the middle, *a*, of a long spring, *D E*, the ends of which rest on two supports, *F* and *G*, it is evident that if the point of suspension is at the middle, *C*, of the beam, and *a* of the spring, the weight of the beam will rest equally on the two supports *F* and *G*, and that the ends of the beam can move up or down or vibrate about the point of suspension, *C*, without affecting the distribution of weight on the supports *F* and *G*. If, now, the timber is suspended from three points, its middle, *C*, and two ends, *A* and *B*, as shown in fig. 303, the ends *A* and *B* being attached to the ends of the springs *b c* and *d e*, the latter resting on the supports *F* and *G*, and connected at their opposite ends to an equalizer, *f g*, whose fulcrum is at *a*, it is evident that each of the end hangers, *b A* and *e B*, must support one-half of that part of the weight of the timber between it and the middle, and that the center hanger, *a C*, must support one-half the weight between the middle and the two ends. Thus the hanger *b A* must support one-half the weight of the timber between *A* and *C*, and *e B* must support one-half of that between *B* and *C*; in other words, the end hangers would each sustain one-fourth of the weight of the timber and the middle one-half of its weight. If the weight of the timber is 1,000 lbs., the end hangers would each sustain 250 and the middle one 500 lbs. The weight of the middle of the timber is hung on the equalizer *f g*, and one-half, or 250 lbs., of it is thus transferred to each of its ends, *f* and *g*, and thence to the hangers *f c* and *g d*, and thus to the springs, so that the ends *c* and *d* of the springs each sustains a weight of 250 lbs.; therefore, as the opposite ends also sustain the same weight, it is evident that each of the springs bears a total load of 500 lbs., or one-half of the weight of the timber. If the ends of a timber supported as shown in fig. 303 are moved up or down about the center point of suspension, it is evident that the distribution of weight would not be affected any more than it was in fig. 302 by a similar movement, because if the ends of the timber move as shown by the dotted lines around the center point of suspension, *C*, the end *A* will ascend as much as *B* descends. The same thing is true of the ends *b* and *e* of the springs and of their opposite ends *c* and *d*, and also of the ends of the equalizer, so that when the timber, springs and equalizer are in the position shown by the dotted lines, it is in equilibrium, just as it was when the timber was horizontal; and therefore the weight on the supports is the same in both cases, thus showing that the load *A B* can move about the center of

Fig. 285.



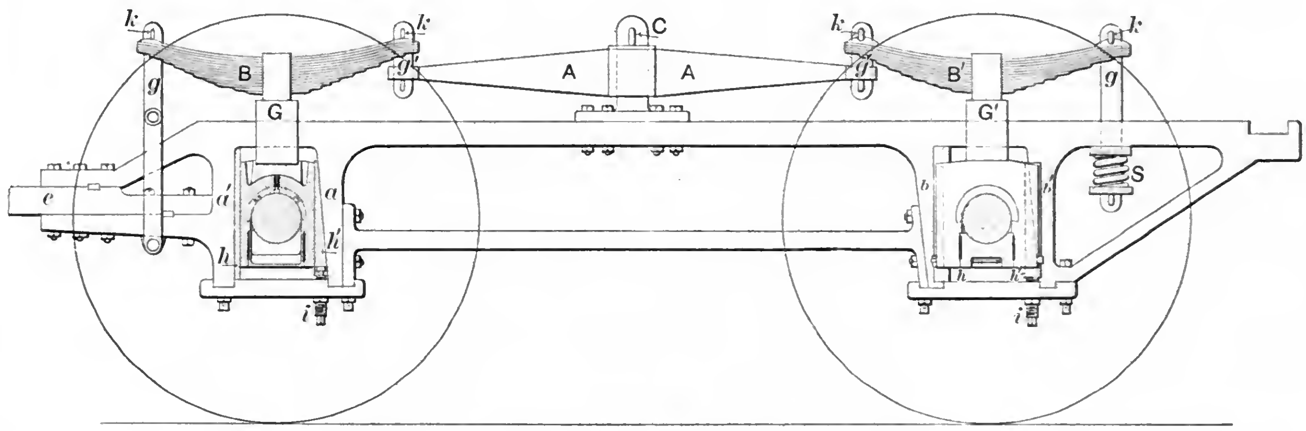


Fig. 286.

* This lever is called an *equalizing lever* or *beam*, or, more briefly, an *equalizer*.

suspension when supported as shown in fig. 303 as freely as it can if arranged as shown in fig. 302. It therefore follows that in the distribution of the weight of each side of the locomotive on the wheels and on the track, it may be regarded the same as though it was supported at one point, which is the fulcrum of the equalizing-lever.

QUESTION 483. *What advantage results from supporting the weight of the back part of the locomotive on two points?*

Answer. If the back part of the locomotive rests on only two points and the front end on the center of the truck, then the whole weight of the engine will be sustained on three points. Now, it is a well-known fact that any tripod, like that on which an engineer's level is mounted, or a three-legged stool, will adjust itself to any surface, however uneven, and stand firmly in any position; whereas if there are more than three points of support, if they are all of the same length, the surface on which they rest must be a plane, otherwise some of them will not touch. All railroad tracks have inequalities of surface, and therefore it is of the utmost importance that a locomotive should be able to adjust itself on its points of support to any unevenness of the track on which it must run. This is possible only when the weight rests on three points of support.

QUESTION 484. *How is the truck constructed?*

Answer. As has already been explained, trucks usually have two pairs of wheels.* These are attached to a frame, 75, 75, Plates III, IV, and V. The axles have boxes called *truck-boxes*, and brass bearings similar to those used on the driving-axles. These boxes work in jaws, also similar to those on the main engine frame, excepting that they have no attachment to prevent them from being worn by the motion of the boxes up and down in the jaws. Fig. 304 is a longitudinal section, fig. 305 a plan, and fig. 306 a transverse section † of a truck. The frame *C D E F*, fig. 305, shown also at *h' h'*, figs. 304 and 306, is of rectangular form, and is forged in one piece. The legs *f f* which form the jaws for the boxes are bolted to the frame as shown in fig. 304. To the lower end of these legs a brace, *g g g*, is bolted, which ties them together. On each side of the truck one spring, *M M*, is placed under the frame and in the reverse or inverted position to that of the driving-springs shown in fig. 286. A pair of equalizing levers, *G G*, is placed on each side of the truck, one of them on the inside of the frame and the other on the outside, as shown in the plan. The ends of these equalizers rest on the top of the truck-boxes, and the springs are attached to the levers at *i i* by the hangers *j j*. The truck-frame rests on the top of the spring-strap, *N*. It is evident that this arrangement of spring and equalizer operates in the same way as that employed for the driving-wheels in distributing the weight on each of the wheels, and that the truck-frame is supported on two points, *k, k*, figs. 305 and 306 The weight of the front end of the engine rests on a cast-iron *center-plate*, *H*. This is sometimes bolted rigidly to transverse bars, *m m*, *m m*, figs. 305 and 306, which are fastened to the sides of the truck-frame. The engravings show what is called a *swing-motion* truck. In this the center plate is suspended from the transverse bars by links *L L' L L'*, so that it can swing or oscillate transversely to the *rails*. These links are suspended from the pins *l l*, *l l*, which pass through the bars *m m*, *m m*, and the center casting or center-plate *H* rests on other pins *l' l'*, which pass through the lower ends of the links. The dotted lines *L a*, *L b* and the arcs *a b*, *a b* show how the center plate *H* swings on the links. The center-pin *S* sometimes has a key underneath the center-plate. This key is intended to prevent the engine from "jumping" off of the truck on a rough track or in case of accident. The annular groove in the top of the center-plate and the projection which fits into it are intended to receive the strain which otherwise would bear against the center-pin and would be liable to break or bend it.

From this description it will be seen that while the truck-frame rests on two points, *k* and *k*, the weight of the engine is supported by the center-plate of the truck. As the back part of the engine rests on substantially the centers of the two equalizers, it will be seen that this distribution of the weight fulfills the conditions of the tripod, or, as it has been called, the "*three-legged principle.*"

QUESTION 485. *How are "pony" or Bissell* trucks with a single pair of wheels constructed?*

Answer. A plan of such a truck, *g s h*, with its details omitted, is shown in fig. 276. Figs. 307, 308 and 309 represent a truck of this kind with all its parts; 307 is a longitudinal section, 308 a plan, and 309 transverse section. It consists of a rectangular frame, *a b*, fig. 276, to which the axles are attached. As explained in answer to Question 436, it also has an A-shaped frame, which is bolted to the back part of the rectangular frame. The apex of this A-shaped part is connected to the main frame of the locomotive by a pin *s*, about which the truck can turn. The rectangular frame is indicated by the letters *C D E F* in figs. 307, 308, and 309, and the A-shaped portion by the letters *r s t*. Such trucks have swing-bolsters, *H*, similar to those used on four-wheeled trucks. They are suspended from links *L L'*, whose lower ends swing in arch of circles indicated by the dotted lines *a b*.

QUESTION 486 *How are the king-bolts of pony trucks arranged?*

Answer. The front king-bolt, *K K*, figs. 307, 308 and 309, is held in a casting *B B*, which is bolted to the engine frame, and bears on the swing-bolster *H*. In some pony trucks this king-bolt is a solid bolt or pin, like that shown in figs. 299 to 301. In other cases it has been found desirable to connect trucks of this kind with the front driving-wheels by an equalizing lever, and the king-bolt is then made hollow, as shown in figs. 307, 308 and 309.

QUESTION 487. *Why are pony trucks connected to the driving-wheels by equalizing levers?*

Answer. This is done for very much the same reason that driving-wheels are connected together in this way, as was explained in answer to Question 480. The connection of a pony truck with the driving-wheels of a locomotive is the invention

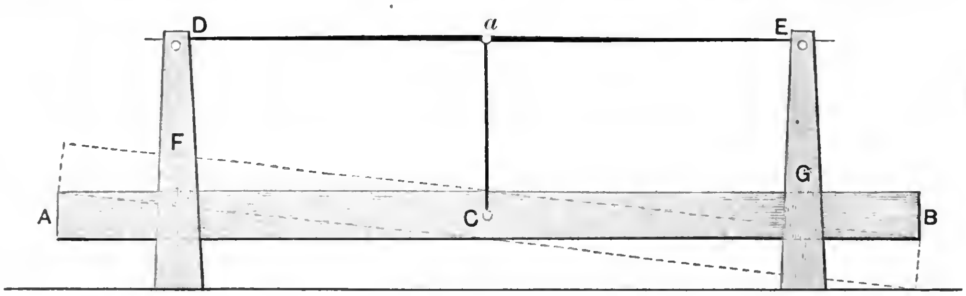


Fig. 302.

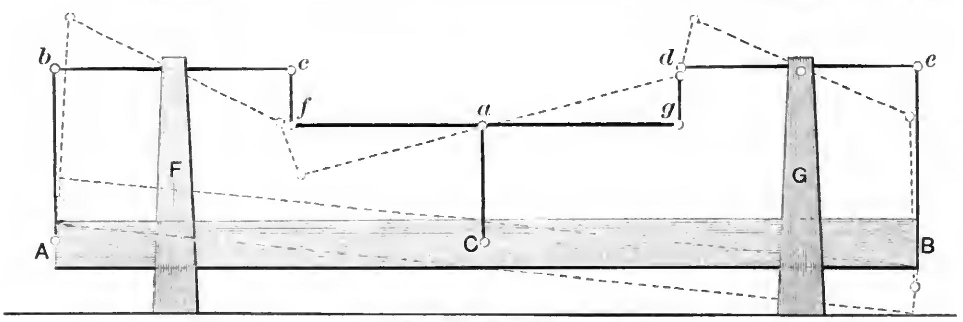


Fig. 303.

Scale ⅜ in. =1 foot.

* In some rare cases three pairs of wheels are employed for locomotive trucks. Six-wheeled trucks are very commonly used under passenger cars.

† The sections are both shown through the center of the truck.

* So named after their inventor, Levi Bissell.

of the late William S. Hudson, who patented the plan in 1864. In his specification he said that "in practice irregularities more or less serious occur at nearly every joint or junction of the ends of the rails, and at certain points in a railroad track, as in passing switches and across tracks, and especially in passing over small obstacles or defects in the road, the inequality in the load which is thrown upon the several wheels becomes very great unless, in addition to the rise of the springs, provision is made by introducing equalizing levers in some manner to induce a unity of action between each pair of wheels and some other pair."

front driving-axle, and *d d d* represents one-half of the periphery of one of the front driving-wheels, and *e e* one-half of the driving-wheel springs. The two ends of a transverse equalizing lever, *h i j*, are connected by hangers *k k* to the front ends of the driving-wheel springs, and the back end *Q* of the lever *O P Q* is suspended to the center *i* of the lever *h i j* by a hanger *m*. It is obvious that if one or both of the front driving-wheels should roll over any object, or a high place in the track, so as to be raised up and thus compress one or both of the springs *d d*, that this action would produce an upward tension on the transverse lever *h i* · the hanger *e* and the back end *Q* of the

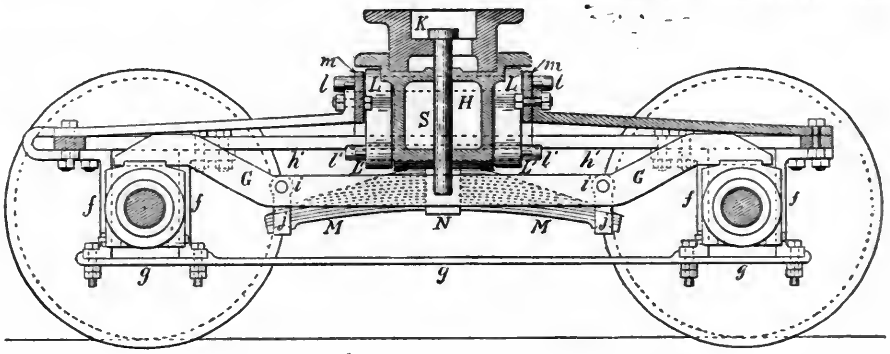


Fig. 304.

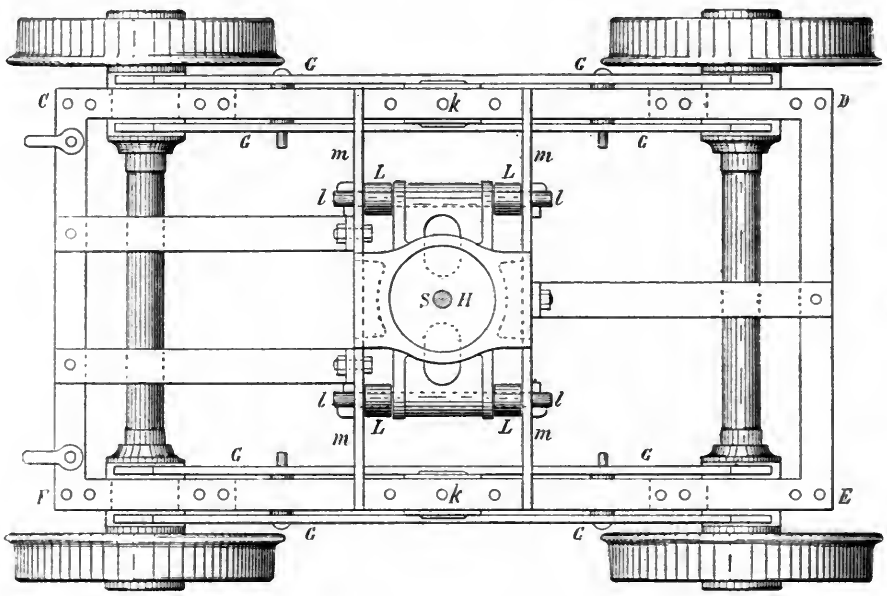


Fig. 305.

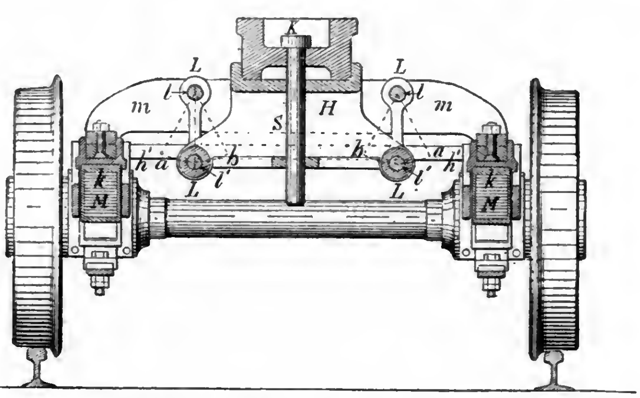


Fig 306.

QUESTION 488. *How are equalizing levers arranged to connect pony trucks with the driving-axles of locomotives?*

Answer. Usually one equalizing lever, *O P Q*, is placed on the middle of the engine instead of using one on each side, as is the ordinary practice with driving-wheels. This lever has a fulcrum at *P*. The front end *O* of the lever is supported in an eye, *c c* (shown clearly in fig. 309), which is formed in the lower end of the center-pin *S*. This pin passes through the hollow king-bolt *K K*, and is supported by a pair of nuts screwed in the upper end, and which bear on the top of the king-bolt. The king-bolt can slide vertically in the casting *B B*. *A* is the lever *O P Q*, and this would exert a downward pressure on the front end *O*, which would be transferred by the center-pin *S* to the top of the king-bolt *K K*, and by it to the bolster *H*, which is suspended by links *L L* to truck frame. Any undue weight resting on one or both of the driving-wheels would thus be transmitted to the truck, and a reverse action will occur if the truck wheels *W W* bear any undue weight.

QUESTION 489. *How does such a truck adjust itself to the curvature of the track?*

Answer. The two center-pins, *S* and *s*, are both attached to the locomotive on its center line, represented by *U V*, fig. 308,

and they cannot move away from that line. If the truck wheels *W W* encounter a curve they must move sideways in relation to the engine. This they are enabled to do by reason of the bolster *H* being suspended from the truck frames by the links *L L L L*. The lower ends of these links can swing in relation to the upper ones, as indicated by the arcs *a b* and *b a*, in fig. 301, or the upper ends can move in relation to the lower ones, as shown in fig. *c*. When the front end of the locomotive enters a curve, the wheels and the truck frame move laterally and carry truck-axle approximates to that of a radius of a curve on which the engine is moving or standing.

QUESTION 490. *How are the springs of a pony truck arranged?*

Answer. In the truck shown by figs. 307, 308 and 309 spiral springs *M M* are used. These are placed underneath the frames, as shown, and ∩-shaped yokes *G G, G G* rest on top of the axle-boxes and are coupled to a cup-shaped casting under the springs, and on which they rest. The form of these yokes is shown partly by dotted lines in fig. 307.

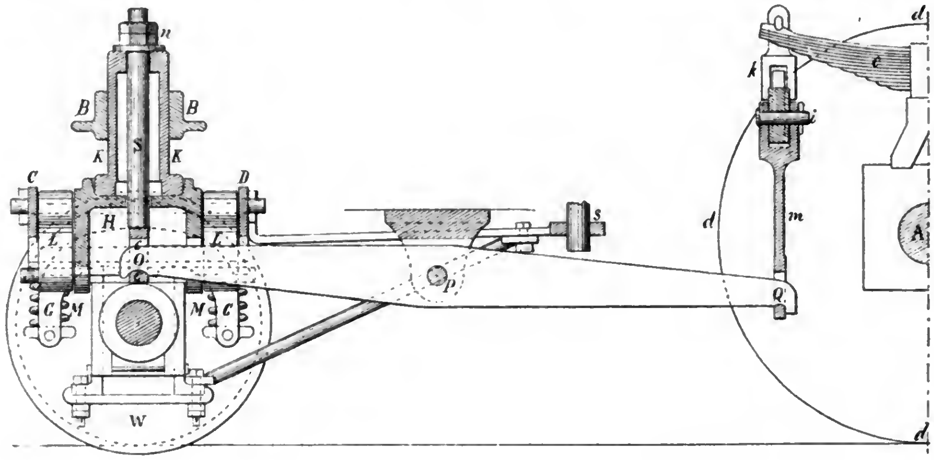


Fig. 307.

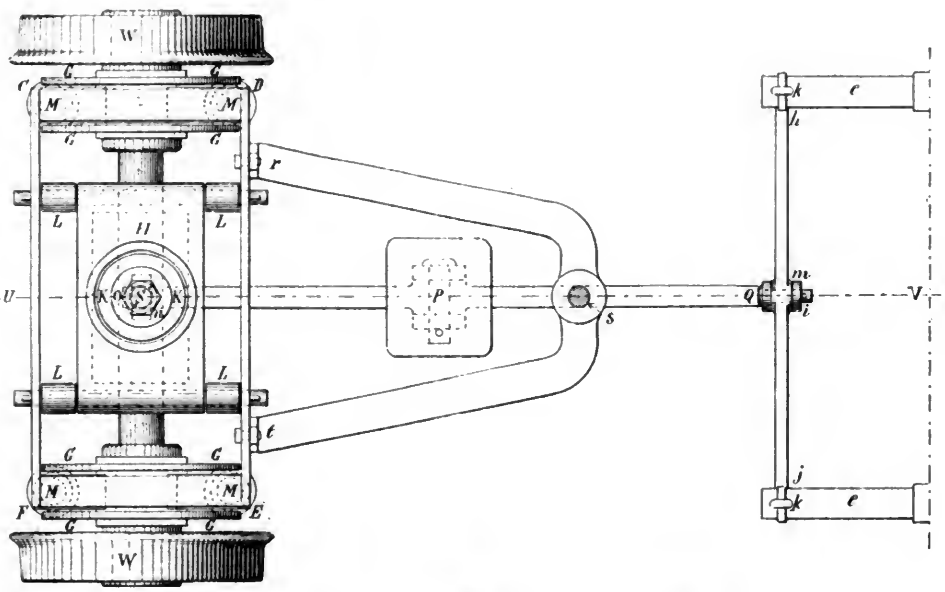


Fig. 308.

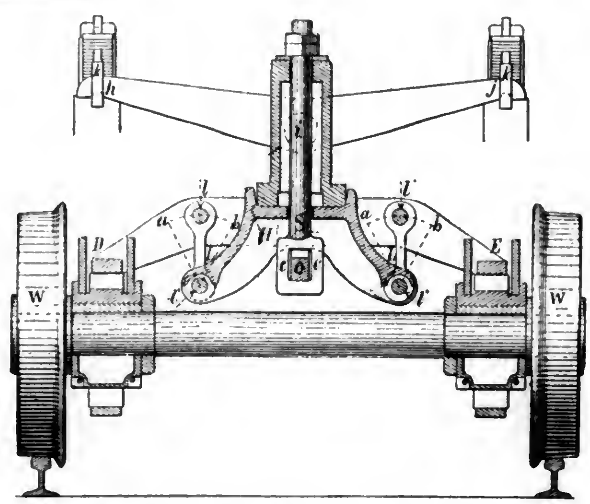


Fig. 309.

the upper ends of the links toward *a a* or *b b*, according to the direction of inclination of the curve, and the bolster *H*, center-pin *S*, and king-bolt *K K*, all retain their central position in relation to the engine. When the truck wheels move laterally their axle, instead of being parallel to the driving-axle, becomes inclined to it, as shown by the dotted center lines *g t* and *c d*, fig. 276, and on a curve the position of the center line of the

QUESTION 491. *What advantage does the use of a pony truck give over one with four wheels?*

Answer. It permits of the front driving-wheels being placed closer to the cylinders than is possible when one pair of the truck wheels is behind the cylinders, as it usually is when a four-wheeled truck is used. If the driving-wheels are located nearer to the cylinders they will bear a larger proportion

of the weight of the engine than they do if they are further back.

CHAPTER XVII.

MISCELLANEOUS.

QUESTION 492. *What is a sand-box of a locomotive, and how is it constructed?*

Answer. A sand-box, 39, Plates III and IV, is usually a cylindrical receptacle which is made of sheet iron with a cast-iron base, and a top of a more or less ornamental design. It

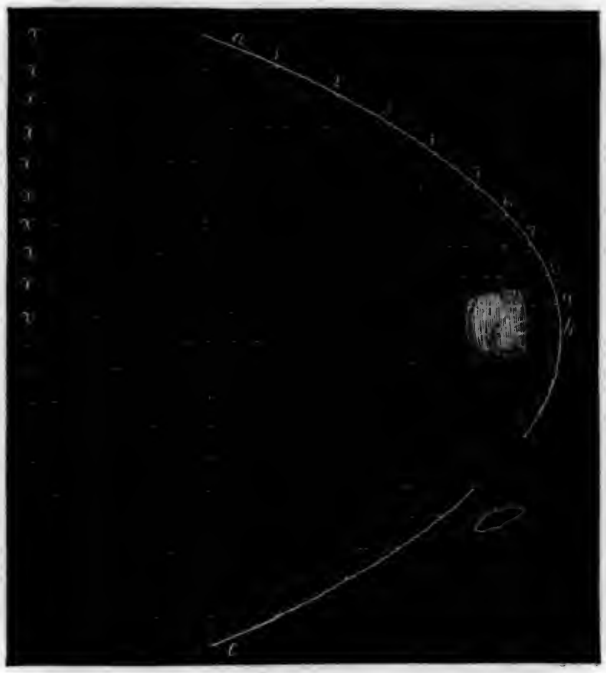


Fig. 310.

is generally placed on top of the boiler and is intended to carry a supply of dry sand, which is scattered on the rails in front of the driving-wheels when the latter are liable to slip. This is done by pipes, 40, Plate III, one on each side of the engine. They lead from the sand-box to within a few inches of the rail. At the upper end and inside the sand-box they each have a valve which is operated by a lever connected to the cab by a rod so that the locomotive runner can open or close the valve at pleasure. The sand-box has an opening on top through which the sand is supplied to the box. This opening has a loose cover to exclude rain and dirt from the sand.

QUESTION 493. *What is the bell,* 41, *Plates III and IV, for?*

Answer. It is used for giving signals of the starting or approach of the engine. It also is located on top of the boiler and is usually hung on a cast-iron frame and rung with a rope, shown in Plate III, connecting it with the cab. Locomotive bells usually weigh from 50 to 100 lbs.

QUESTION 494. *What is the signal-gong?*

Answer. It is a gong-bell with a hammer or clapper attached to it, and fastened, usually, to the under side of the roof of the cab. The train bell-cord is connected to the hammer, by which the bell can be rung from any part of the train to signal to the engineer to start or stop the engine.

QUESTION 495. *What is a locomotive head-light?*

Answer. It is a large lamp, 35, Plates III and IV, placed in front of the locomotive to signal its approach at night and also to illuminate the track for the locomotive runner.

QUESTION 496. *How is a head-light constructed?*

Answer. The lamp has what is called an Argand burner; that is, a burner with a hollow cylindrical wick through the center of which a current of air circulates which thus supplies the flame with a larger quantity of air than is possible if the air can come in contact with the burner only on the outside. The result is that the combustion of an Argand burner is much more brilliant than that of ordinary burners. In order to throw all the light on the track the burner is placed inside of a concave reflector, *a b c*, fig. 310, which is of a *parabolic* form. One of the peculiarities of this form of reflector is that if a light is placed in its focus *f* the rays will be reflected from its surface in parallel lines. Thus, let *a b c*, fig. 310, represent a section of such a reflector. Now, if a light be placed in the focus *f* the rays will strike against the reflector in the direction of the dotted lines *f* 1, *f* 2 . . . *f* 9, etc., and be reflected in straight horizontal lines 1 *x*, 2 *x*, 3 *x*, etc., and thus be thrown directly in front of the engine. The reflectors are usually made of copper and plated with silver.

The lamps and reflectors for head-lights are enclosed in a rectangular case which is placed on top of the smoke-box, or is supported on two brackets bolted to the front of the smoke-box. On these brackets a wooden shelf is fastened on which the head-light rests.

QUESTION 497. *What are the running-boards and hand-rails?*

Answer. The *running-boards* are narrow platforms, made of wood or iron, 56, 56, Plate III, placed on each side of the boiler to enable the locomotive runner or fireman to go from the cab to the front end of the engine when it is running. The hand-rails, 57, 57, are brass or iron pipes attached to the top of the boiler and extending from the cab to the smoke-box, and are placed there, as their name indicates, for persons on the running-board to take hold of.

QUESTION 498. *What provision is made for removing from the track obstacles such as cattle, fallen rocks, etc., which may be in front of locomotives?*

Answer. What is called a *cow-catcher* or *pilot*, 38, Plates III and IV, is attached to the front of the locomotive. This is usually made of wood, and consists of a triangular frame at the bottom, which is supported so that it is a few inches above the tops of the rails. Straight pieces of wood of about $2\frac{1}{2} \times 4$ in. section are fastened to this frame and also to a horizontal piece which is bolted to the bumper-timber. These pieces when arranged in this way, and only a few inches apart, give to the cow-catcher a peculiar curved form—somewhat resembling that of the mould-board of a plow—which is very well adapted for throwing any obstacles from the track. Sometimes these pieces are placed horizontally instead of being inclined up and down. Cow-catchers are also in some cases made of round iron bars or angle iron. They are always bolted securely to the bumper-timber and strengthened by strong iron braces attached to the bottom frame at the front and back. These braces are usually fastened at the other end to the bumper-timber, but are sometimes attached to the bed-plates of the cylinder.

There is also usually a strong *pushing-bar*, 79, attached with a bolt and hinged joint to the bumper-timber. This is shown in Plates IV and V in the position it occupies when not in use. It is used in pushing cars, as very often there is not room for the pilot under the end of the car. In using it, it is raised up, and the front end is then coupled to the draw-head of the car.

Iron plates and scrapers are often attached to the pilots in winter to remove snow from the track.

QUESTION 499. *What is the foot-board or foot-plate of a locomotive?*

Answer. It is a wrought or cast-iron plate, 95, Plate IV, which extends across and rests upon the two frames at the back part of the locomotive and behind the boiler, and on which the locomotive runner and fireman stand. It also unites the two frames very securely, and furnishes an attachment for the draw-bar.

QUESTION 500. *What other purpose is the foot-board sometimes made to serve?*

Answer. It is sometimes made much heavier than is necessary for strength in order to increase the weight, and thus the

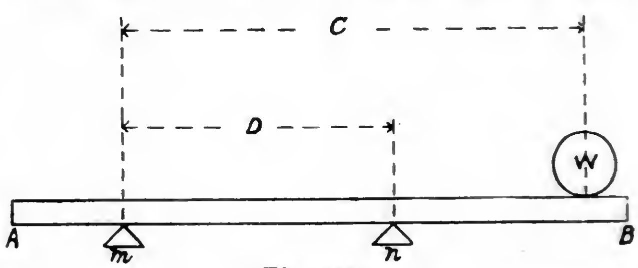


Fig. 311.

adhesion, on the driving-wheels. It is a fact often not suspected that any weight placed on the back end of an ordinary locomotive will increase the load on the driving-wheels by an amount considerably greater than that of the weight itself. The reason of this is that the locomotive rests on the center of the truck and the centers of the equalizers, and therefore the weight, if applied to the back end of the engine, gains considerable leverage. This will be clear if we take a beam, *A B*, and rest it on two supports, *m* and *n*, fig. 311. If, now, we put a weight *W* on the end, overhanging the point of support, the weight which will rest on *n* will be equal to that of *W* multiplied by its distance *C* from *m* and divided by the distance *D* between *m* and *n*. Thus if a foot-board weighs 1,000 pounds, and its center of gravity is $5\frac{1}{2}$ ft. behind the center of the equalizer,

and the latter 14 ft. from the center of the truck, then the weight thrown on the driving-wheels will be equal to

$$\frac{1{,}000 \times 19\frac{1}{2}}{14} = 1{,}393 \text{ pounds.}$$

The same thing is, of course, true of any other weight placed on the back end of the engine.

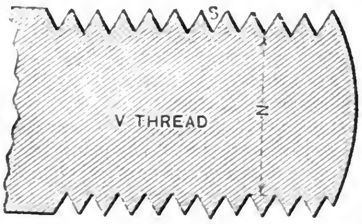
QUESTION 501. *What are the "wheel-guards" of a locomotive?*

Answer. They are sheet iron covers, 61, 61, Plate III, over the upper half of the periphery or tread of the wheels, and are placed there to protect the engine from the dirt and mud which adhere to the wheels, and are then thrown off on the machinery by the centrifugal force.

QUESTION 507. *What is the usual form of the threads of screws?*

Answer. Until a few years ago the most common form was what is called the V-thread, represented in fig. 312 (and on an exaggerated scale in fig. 313), which was made sharp at both the top and bottom. It is evident that if such a thread for one screw is made very pointed, and that for another is blunt, that the nut for the one will not fit the other accurately, and also that if a nut has eight threads to the inch, it will not fit on a bolt with nine. Owing to the fact that, for a long time, no common standard had been agreed upon for the form, proportions or pitch of screws, there was a very great diversity in these respects in the screws which have been used in the construction of locomotives and other machinery. In 1864 the inconvenience and

Fig. 312.



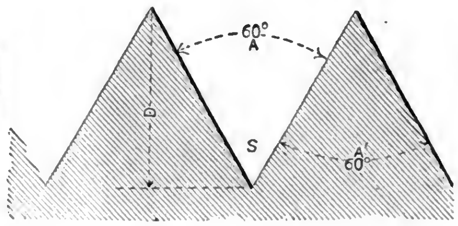
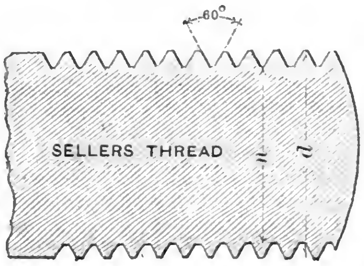


Fig. 313.

Fig. 314.



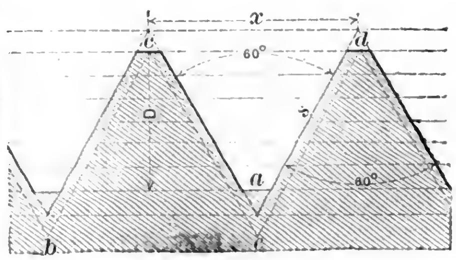


Fig. 315.

QUESTION 502. *What are "check" or "safety chains?"*

Answer. There are two kinds of such chains, the one, 78, Plates III and IV, attached to the trucks and frames of the locomotive and the tender. The object of these chains is to prevent the trucks from turning around and getting crosswise of the track if the trucks should leave the rails. The other kind of safety chains, 50, Plates III and IV, connect the engine to the tender, so that, in case the draw-bar or coupling-pins should break, the two will not separate. Great care should be exercised to attach the truck chains so as to be strong enough to resist the strains to which they will be subjected in case the trucks run off the track. The grossest carelessness and ignorance are often shown in the construction of these parts.

QUESTION 503. *Where should steps be placed on locomotives?*

Answer. Steps should be attached to the back end of the locomotive, as shown by 101, Plates III, IV and V, to enable the men to get on and off the foot-board. Such steps are usually made too small, so that those who use them are liable to miss their foothold, especially at night. Steps should also be attached to the pilots of locomotives for men to stand on in coupling the locomotive to cars.

CHAPTER XVIII.

SCREW-THREADS, BOLTS, AND NUTS.

QUESTION 504. *How must the screws of bolts and nuts be made, in order to fit each other?*

Answer. Each size of screw must be made of exactly the same diameter, and their threads of the same form and proportions and *pitch*.

QUESTION 505. *What is meant by the "pitch" of a thread?*

Answer. It is the distance the thread progresses lengthwise of the screw in one revolution. Thus if a single-threaded screw has ⅛ of an inch pitch, it means that the threads are ⅛ of an inch apart measured from the center of one thread to the center of that next to it, and therefore there are eight threads to each inch in length of the screw.

QUESTION 506. *What is meant by a "single-threaded" screw?*

Answer. It means a screw with but one thread instead of two or more. Thus if we take a string and wind it around a pencil, it will represent a single-threaded screw, and if we take two or three strings and wind them parallel to each other, they will represent double or treble-threaded screws. The latter kinds are seldom or never used on locomotives, so that in the following discussion only single-threaded screws will be referred to.

confusion from this cause became so great that it attracted the attention of the Franklin Institute of Philadelphia, and a committee was appointed by that association to investigate and report on the subject. That committee recommended the adoption of the Sellers system of screw-threads and bolts, which was devised by Mr. William Sellers, of Philadelphia. This same system was subsequently adopted as the standard by both the Army and Navy Departments of the United States, and then by the Master Mechanics' and Master Car Builders' associations, so that it may now be regarded, and in fact is called, the United States standard, but the design is due to Mr. Sellers.

QUESTION 508. *In establishing a standard system of screws and threads, what is the first thing which must be determined?*

Answer. The number of threads to the inch, or the pitch of the threads for screws of different diameters.

QUESTION 509. *What is the standard for the number of threads to the inch for the different sized screws of the Sellers system?*

Answer. The number of threads with their other proportion is given in the table at the end of this chapter.

QUESTION 510. *What is the form of the thread of this standard?*

Answer. The form is shown in fig. 314, and on an exaggerated scale by fig. 315. It is similar to the V-thread, excepting that it is flattened at the top and bottom.

QUESTION 511. *What advantages has the Sellers form of screw-threads over the old V-form?*

Answer. The flattened point or edge makes the thread less liable to injury by being battered, and the diameter—and consequently the strength—of a screw with a Sellers thread at *n*, fig. 315, at the root of the thread, is considerably greater than a thread of the V-form.

QUESTION 512. *What other reasons are there for the adoption of this form of thread?*

Answer. It has already been pointed out that if a screw is made with a "blunt" thread it will not fit a nut with very acute or "sharp" thread; or, if the thread of the bolt is acute and that in the nut obtuse, they will fit imperfectly. It is therefore necessary in a standard system to fix upon the angle which the sides of the thread shall bear to each other. This in the United States standard system was determined by Mr. Sellers at 60 degrees, because that angle is easily laid off without special instruments* and is, perhaps, as good as or better than any other form for the threads.

* This can be done by drawing a circle of any diameter, and subdividing the circumference into six equal parts with the radius. Lines drawn from the points of division to the centre will have an inclination of 60 degrees to each other.

It is obvious that if a tool is ground with its sides at an angle of 60 degrees to each other, if the point is made sharp, after a very little use it will be worn more or less so that the bottom of the thread will not be cut perfectly sharp, and therefore it will be difficult to make bolts and nuts with threads of this form fit each other accurately. It is also plain that the sharp edge of a thread gives very little strength to the screw, and yet diminishes that of the bolt very materially. It will also be impossible to measure the diameter of the screw at the bottom of the thread if it is made sharp, as its depth will vary as the point of the tool wears, and it is almost impossible to measure the diameter of such a screw accurately with ordinary calipers. To

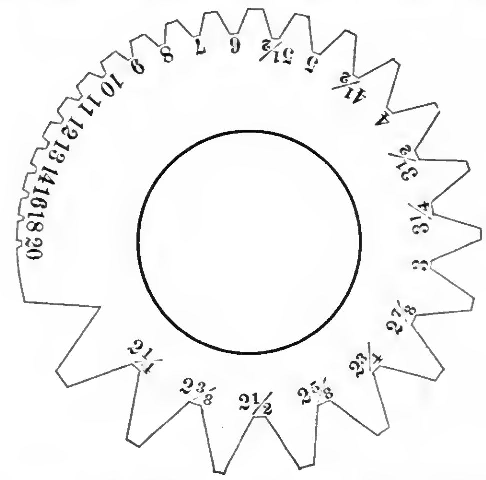


Fig. 316.

obviate these evils the standard threads are made flat on the top, and it is evident—as has been pointed out—that a similar shape at the bottom will give increased strength to the bolt as well as conform to and fit the thread in the nut. To give this form requires only that the point of the cutting tool shall be taken off, and it is evident that then this form of thread can be cut in a lathe with the same tool and in the same manner as the sharp thread. The width of the flat top and bottom should, of course, bear a definite proportion to the size or pitch of the thread.

QUESTION 513. *What are the proportions of the standard threads?*

Answer. The rule given by Mr. Sellers for proportioning the thread is as follows: "DIVIDE THE PITCH, OR, WHAT IS THE SAME THING, THE SIDE OF THE THREAD, INTO EIGHT EQUAL PARTS; TAKE OFF ONE PART FROM THE TOP AND FILL IN ONE PART IN THE BOTTOM OF THE THREAD: THEN THE FLAT TOP AND BOTTOM WILL EQUAL ONE-EIGHTH OF THE PITCH, THE WEARING SURFACE WILL BE THREE-QUARTERS OF THE PITCH, AND THE DIAMETER OF SCREW AT BOTTOM OF THE THREAD WILL BE GIVEN IF WE DIVIDE 1.299 BY THE NUMBER OF THREADS PER INCH AND DEDUCT THE QUOTIENT FROM THE OUTSIDE DIAMETER OF THE SCREW.

To show the form and proportions of the thread fig. 315 has been drawn eight times the size of a thread for a bolt one inch in diameter, so as to represent the different parts clearly; x represents the pitch and D the depth of the thread; d, fig. 314, represents the outside diameter of the screw, and n the diameter at the bottom or root of the thread. The width of the flat part of the thread at the top and the bottom of the threads is shown at c, d and a, fig. 312, and s indicates the length of the side or wearing surface of the thread.

The dotted lines $b\ c$, $c\ e$, $e\ d$ show the form of a V-thread, and the distance from a to e shows—on an exaggerated scale—how much more metal must be cut away at the root of the thread if it is made of the V-shape than if it is of the standard Sellers form.

For practical use in the shop a gauge like that shown in fig. 316 will be found convenient for grinding the tools to the proper form for making the standard screws. With this gauge the screw-cutting tool can first be ground to the proper angle by fitting it to the deepest notch, and the requisite quantity should then be taken off the point by fitting it to the notch representing the form of thread for the sized bolt or number of threads to the inch which it is intended to cut.

Wherever this standard for threads is used, if any pretense at all is made to accuracy of workmanship, careful attention should be given to the form and proportion of the threads as well as to the number to the inch.

QUESTION 514. *What other precaution must be taken to secure interchangeability of screw bolts and nuts?*

Answer. Great care must be taken that the diameters of the screws are accurately maintained to the standard sizes. The diameters of the standard sizes of screws are given in the table at the end of the chapter. It has been a common practice to make screws somewhat larger than these sizes because iron is often rolled larger in diameter than its nominal size, and then the superfluous metal must be cut away to reduce the screw to the standard size. It should be distinctly known that there are no standard screws for bolts and nuts which are a small fraction of an inch larger or smaller than the diameters given in the tables, and that a screw slightly larger or smaller in diameter than the sizes given does not conform to the standard.

QUESTION 515. *What has been done to secure uniformity in the diameters of screws?*

Answer. The Master Mechanics' and the Master Car Builders' associations have adopted limits for the diameter of round bar iron. It has been specified by these associations that such iron shall not vary from its nominal size more than the amount given in the following table:

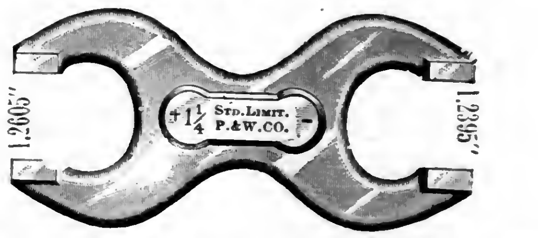
LIMITS OF SIZE OF ROUND ROLLED IRON.

Nominal Diameter of Iron. Inches.	Maximum or + Size. Inches.	Minimum or — Size. Inches.	Total Variation. Inches.
1/4	.2550	.2450	.010
5/16	.3180	.3070	.011
3/8	.3810	.3690	.012
7/16	.4440	.4310	.013
1/2	.5070	.4930	.014
9/16	.5700	.5550	.015
5/8	.6330	.6170	.016
3/4	.7585	.7415	.017
7/8	.8840	.8660	.018
1	1.0095	.9905	.019
1 1/8	1.1350	1.1150	.020
1 1/4	1.2605	1.2395	.021

Caliper gauges, like that shown in fig. 317, are made by the Pratt-Whitney Company, of Hartford, Conn., for measuring bar iron. The two ends of the gauges are made of the maximum and minimum dimensions given in the table, and the associations already referred to have recommended "that round iron of the nominal standard sizes be made of such diameter that each size *will* enter the large or + end of the gauge intended for it, *in any way*, and will *not* enter the small or — end *in any way*.*

In buying taps and dies the purchaser should see that they conform in every respect to the standard, and in making specifications for new work similar care should be exercised to secure the true standard, form, and proportion of screws. In

Fig. 317.



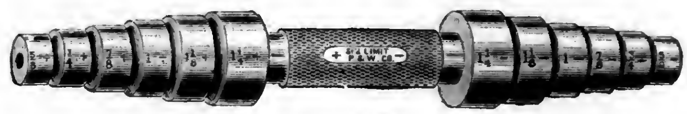


Fig. 318.

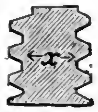
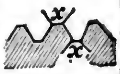
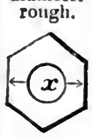
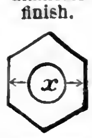
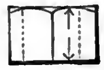
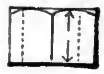
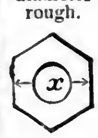
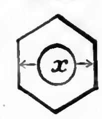
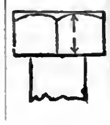
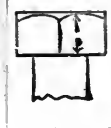
many shops the workmen who have the care of those tools are entirely ignorant of the peculiarities of the Sellers system, and have only the vague idea that so long as they get the proper number of threads to the inch they are doing all that is necessary to secure uniformity. Unless, therefore, some care is exercised to insure accuracy of workmanship in this department, the adoption of a "standard" for screws will not insure the advantages which would result from uniformity of screws and threads.

QUESTION 516. *What is the usual shape of nuts?*

Answer. The most common shape is square or hexagonal, as shown in figs. 319-322, but they are sometimes made cylin-

* Fig. 318 is a reference gauge which is used for testing the caliper gauges shown in fig. 317.

TABLE OF DIMENSIONS OF SELLERS' STANDARD SCREW-THREADS, NUTS AND BOLTS.

Screw-Threads.				Nuts.				Bolt Heads.			
Diameter of screw.	Threads per inch.	Diameter at root of thread.	Width of flat.	Short diameter rough.	Short diameter finish.	Thickness rough.	Thickness finish.	Short diameter rough.	Short diameter finish.	Thickness rough.	Thickness finish.
											
1/4	20	.185	.0062	1/2	7/16	1/4	3/16	1/2	7/16	1/4	3/16
5/16	18	.240	.0074	19/32	17/32	5/16	1/4	19/32	17/32	19/64	1/4
3/8	16	.294	.0078	11/16	5/8	3/8	5/16	11/16	5/8	11/32	5/16
7/16	14	.344	.0089	25/32	23/32	7/16	3/8	25/32	23/32	25/64	3/8
1/2	13	.400	.0096	7/8	13/16	1/2	7/16	7/8	13/16	7/16	7/16
9/16	12	.454	.0104	31/32	29/32	9/16	1/2	31/32	29/32	31/64	1/2
5/8	11	.507	.0113	1 1/16	1	5/8	9/16	1 1/16	1	17/32	9/16
3/4	10	.620	.0125	1 1/4	1 3/16	3/4	11/16	1 1/4	1 3/16	5/8	11/16
7/8	9	.731	.0138	1 7/16	1 3/8	7/8	13/16	1 7/16	1 3/8	23/32	13/16
1	8	.837	.0156	1 5/8	1 9/16	1	15/16	1 5/8	1 9/16	13/16	15/16
1 1/8	7	.940	.0178	1 13/16	1 3/4	1 1/8	1 1/16	1 13/16	1 3/4	29/32	1 1/16
1 1/4	7	1.065	.0173	2	1 15/16	1 1/4	1 3/16	2	1 15/16	1	1 3/16
1 3/8	6	1.160	.0208	2 3/16	2 1/8	1 3/8	1 5/16	2 3/16	2 1/8	1 3/32	1 5/16
1 1/2	6	1.284	.0208	2 3/8	2 5/16	1 1/2	1 7/16	2 3/8	2 5/16	1 3/16	1 7/16
1 5/8	5 1/2	1.389	.0227	2 9/16	2 1/2	1 5/8	1 9/16	2 9/16	2 1/2	1 9/32	1 9/16
1 3/4	5	1.491	.0250	2 3/4	2 11/16	1 3/4	1 11/16	2 3/4	2 11/16	1 3/8	1 11/16
1 7/8	5	1.616	.0259	2 15/16	2 7/8	1 7/8	1 13/16	2 15/16	2 7/8	1 15/32	1 13/16
2	4 1/2	1.712	.0277	3 1/8	3 1/16	2	1 15/16	3 1/8	3 1/16	1 9/16	1 15/16

drical, as shown in figs. 323 and 324, with grooves cut on the outside to hold a wrench.

QUESTION 517. *Why is it often essential to adopt some means to prevent nuts from turning or unscrewing?*

Answer. When bolts and nuts are exposed to vibration, it is found that a slackening is very liable to occur, so that the excessive vibration on locomotives requires that many of the nuts should be locked in some way.

QUESTION 518. *How are nuts prevented from turning?*

Answer. The simplest plan, and the one which is most frequently employed, is that shown in figs. 325 and 326, which is simply a second nut screwed on over the first and tightened down upon it. Lock nuts are usually made thinner than the main nut, and when that is the case, it is argued that the thinnest nut should be screwed on the bolt first, because if the second nut is screwed down hard on the first one, the strain on the bolt is borne by the one last screwed on.

Fig. 319. Fig. 321. Fig. 323. Fig. 325.

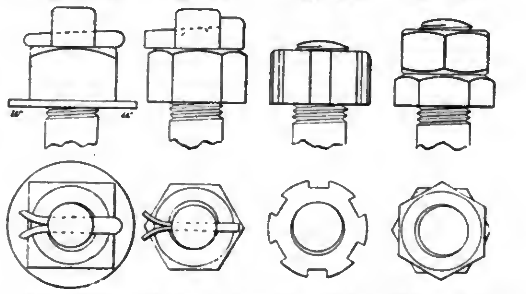


Fig. 320. Fig. 322. Fig. 324. Fig. 326.

When lock nuts are used, if the total thickness of the two nuts is equal to about one half more than the ordinary proportion for the thickness of nuts, it will be found that sufficient has been done to insure a perfect locking.

When the object is merely to prevent nuts from unscrewing and being lost, what are called *split keys* or *cotters* are used. These are sometimes round, tapered pins, shown in figs. 319 and 320, which are divided or split so that the two parts can be bent into the form shown in fig. 320. In other cases they are made of flat pieces of metal, as shown in figs. 321 and 322, which are bent as shown in fig. 322.

QUESTION 519. *What are the shapes of bolt-heads?*

Answer. They are made in a variety of forms according to their use, but usually they are either square or hexagonal, the same as nuts.

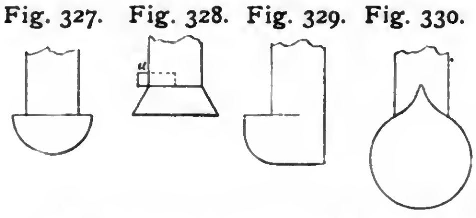
QUESTION 520. *In what other forms are bolt-heads made?*

Answer. Fig. 327 represents a bolt with a hemispherical head, and fig. 328 one with a countersunk head. The latter form is used when a projecting head would be in the way of something else. To prevent the bolt from turning when a hemispherical or countersunk head is used, a hole is sometimes drilled into the side of the bolt and a pin *a*, fig. 328, is fitted into it. This pin rests in a corresponding cavity cut in the side of the hole in which the bolt fits.

Fig. 329 represents a hook-headed bolt, which is sometimes used to fasten tires on wheel centers. Fig. 330 is the form of bolt-head used to move the wedges which form the wearing surface for driving-axle boxes.

QUESTION 521. *Are there any standard sizes for bolt-heads and nuts?*

Fig. 327. Fig. 328. Fig. 329. Fig. 330.



Answer. Yes, proportions were devised by Mr. Sellers and were adopted by the associations already referred to. These are given in the table at the end of this chapter.

QUESTION 522. *What is a washer?*

Answer. A washer, shown at *w w*, fig. 319 and in fig. 320, is a ring of metal or other material, which is put under a bolt-head or nut to give it a fair bearing. Washers are also put between bolt-heads or nuts when they bear on wood or other yielding material to increase the area of their bearing.

QUESTION 523. *What is a stud?*

Answer. A stud is a bolt with a nut in place of a head. Studs are screwed into their place and are provided with nuts instead of heads, so that the stud need not be unscrewed to loosen or remove the parts which it secures or fastens. Studs are generally used to make attachments to cast-iron, because a thread cut in cast-iron is liable to be injured by screwing and unscrewing a bolt into and from it.

(TO BE CONTINUED.)

Manufactures.

A New Combined Door Spring and Check.

THE accompanying illustrations represent a combined door spring and check, which presents some new and excellent features. Fig. 1 is a perspective view and fig. 2 a plan; the operation of the spring will be readily understood from the engravings. The frame *A* is fixed to the door casing, and the bracket *D* to the door, and the oscillating lever *C*, which is pivoted to

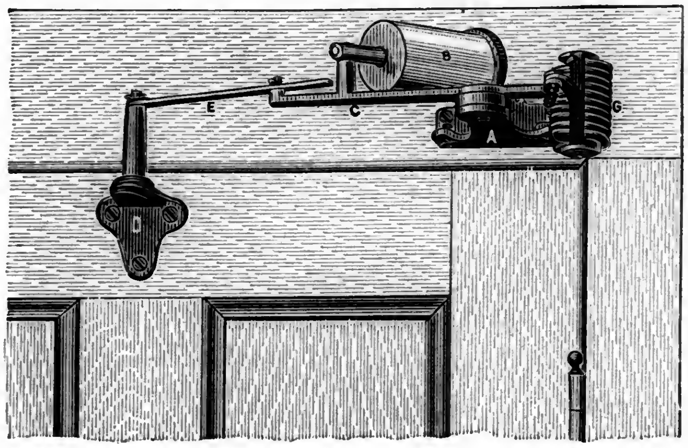


Fig. 1.

the other end of the frame *A*, is connected to the bracket *D* by the link *E*. The spring *G* carries two toggle-arms, one of which is pivoted to the frame, and the other attached to the short arm of the lever *C* by a flat link chain. The air cylinder *B* is pivoted to the frame *A* at its base, while its piston-rod is pivoted to the lever *C*. The piston of this air cylinder is of the ordinary cup pattern with a valve in the center. This valve consists of the tapered end of the piston-rod fitting into a seat in the piston, and is so arranged that when the piston is drawn backward the valve

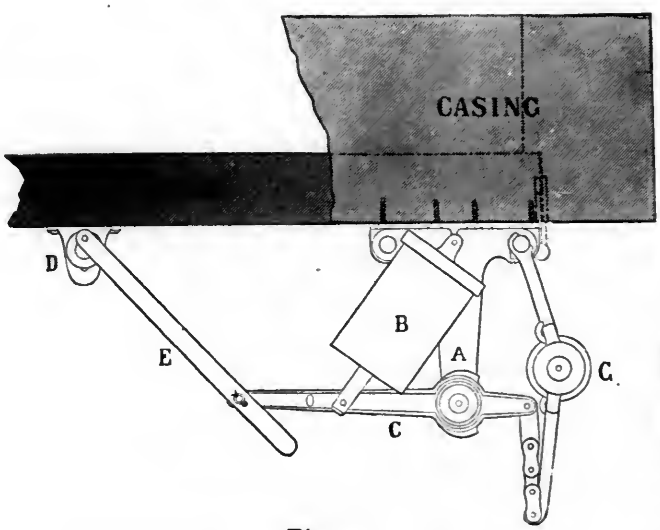


Fig. 2.

is opened and allows the air to pass through; when the motion is reversed the valve is closed and the air compressed in front of the piston. To allow a slow closing motion, an arrangement is made for the escape of a small volume of air through the piston by means of a very small slot cut in the valve seat.

When the door is opened the lever *C* draws the chain toward its pivot until engaged by the eccentric segmental drum, around which it winds so that when the door is wide open the spring is at its maximum tension, while with the chain around the drum it imparts its minimum power to the door. Thus the first motion of closing is slow, but is gradually increased in speed as it proceeds until checked by the air cushion in the cylinder. The greatest power is exerted upon the door by the spring when it is at its least tension and the door is nearly shut; this is for the purpose of overcoming the resistance of the latch, wind, etc.

These springs and checks are so made that they can be used for either right or left-hand doors by a very simple change, which can be effected in a minute, and consists in merely reversing the lever and bracket. It is readily adjusted by means of the hole and small pins provided in the lever and connecting rod *E*.

Several sizes of these springs and checks are made by the manufacturers, the Russell & Erwin Manufacturing Company, of New Britain, Conn., and New York. One of these is especially intended for car doors, and is now extensively used on the Boston & Albany, and on several other New England roads.

The spring fulfills very well all the requirements of a good door spring. It is simple in all its parts, can be quickly and easily put up, and is not liable to get out of order, while it prevents entirely the too quick closing and banging of the door, which is an unpleasant feature of almost all springs now in use.

Blast Furnaces of the United States.

THE *American Manufacturer*, in its usual monthly tables, gives the condition of the blast furnaces on October 1, and sums up as below.

"The totals are as follows:

	In Blast.		Out of Blast.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	73	12,983	96	11,696
Anthracite	99	29,586	97	24,548
Bituminous	138	87,141	89	42,845
Total	310	129,710	282	79,089

"Our table shows that the number of furnaces in blast on October 1 was 310, compared with 298 in blast on September 1—an increase of 12. The increase by classes is divided as follows: Charcoal, 5; anthracite, 1; bituminous, 6. The weekly capacity of the furnaces in blast was 129,710 tons, compared with 126,082 tons on September 1, the increase being distributed as follows: Charcoal, 360 tons; anthracite, 640 tons; bituminous, 2,628 tons.

"The appended table shows the number of furnaces in blast October 1, 1888, and on October 1, 1887, with their weekly capacity:

	Oct. 1, 1888.		Oct. 1, 1887.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	73	12,983	73	15,171
Anthracite	99	29,586	122	36,044
Bituminous	138	87,141	151	93,423
Total	310	129,710	346	144,638

"This table shows that the number of furnaces in blast October 1 last was 36 less than at the same date in 1887, the decrease being distributed as follows: Charcoal, no change; anthracite, 23; bituminous, 13. The weekly capacity of the furnaces blowing was 129,714 tons: at the corresponding date last year, 144,638—decrease, 14,928 tons."

Twin-Screw Steamers.

TWIN screws, driven by triple-expansion engines, have in so many cases proved more effective and economical than the side-wheelers and propellers built a few years ago, that the question of converting old side-wheel steamers into twin screws is likely to arise. The experience of an English railroad company in this direction is therefore interesting. The London & North-western Railway some months since placed their paddle-wheel steamer *Duchess of Sutherland* (built in 1869) in the hands of Messrs. Laird Brothers for conversion into a twin-screw steamer, with the expectation that her efficiency for their cross-channel cattle trade would be improved, and that considerable gain in economy would result from the introduction of more modern machinery. The work has been completed, and on a recent trial trip the vessel ran $14\frac{1}{2}$ knots, the engines developing 1,400 H. P. The old machinery, side-wheels, and boxes were removed, but the forward and after sponsons or guards and their houses on each side are retained and connected, the houses forming quarters for the ship's officers, store rooms, etc. The old side-wheel space is decked over and formed into a large additional space for cattle. The necessary alterations have been made about the stern of the vessel, and stern tubes and brackets fitted, and the arrangement of engine keelsons, bulkheads, coal-bunkers, etc., has been modified to suit the new machinery. This consists of two sets of triple-expansion engines having cylinders $16\frac{1}{2}$ in., 26 in., and 41 in. diameter, with a stroke of 30 in., and working at 150 lbs. pressure, steam being provided by

two double-ended cylindrical Scotch steel boilers. The carrying power of the vessel has been increased by about 190 tons, large additional deck space for cattle gained, while the net register tonnage has been reduced by 247 tons. The speed has been considerably increased, and the consumption of fuel reduced.—*Marine Journal.*

A New Railroad Ditcher.

THE accompanying illustrations show machinery which is designed to take a place between the wheel scraper and steam shovel, and to fill a vacancy as a ditcher in railroad maintenance of way, doing away with the expense and weight of the steam shovel, as well as the expense incurred in hauling with the wheel scraper at long distances.

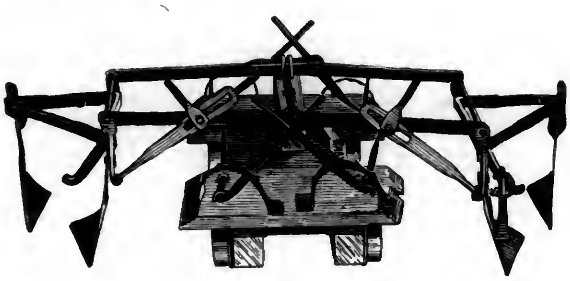


Fig. 1.

In these illustrations fig. 1 shows the plows; fig. 2 is a front view of the scrapers, and fig. 3 a perspective view of the same.

The appliances consist of plows and scrapers attached to the sides of a car so as to excavate to a considerable depth below or above the rail. The plows are necessarily of strong construction, enough to loosen any earth which can be removed without blasting. The side-arms, which are pivoted on the center beam of the car and to the plow-beams, allow the plowing to any height from 2 ft. below the rail to the top of the car, and keep the plows parallel to the track. The brace-rod is hooked into an eye on the side of the forward plow and slotted over a stud on the fore side-arms, where it is fastened with a nut so as to maintain the desired angle between plows and car. The scraper boxes on the excavators being connected to the car by arms of similar length and range, cause the scrapers to follow exactly in the line of loosened material, thus allowing a much lighter construction of scrapers in all their parts than would be necessary if they had to be drawn through unplowed ground.

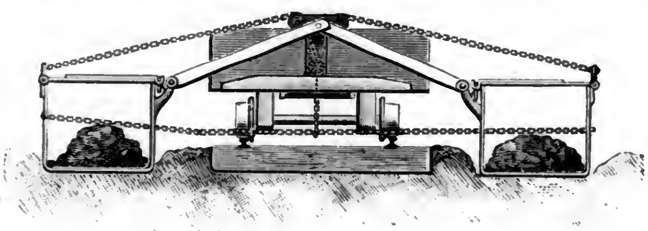


Fig. 2.

Fig. 3.

The weight of this excavator does not greatly exceed that of an ordinary dump car. The center of gravity is lower than that of any car of equal capacity. The scrapers for a 3-ft. gauge car are 3 ft. wide, 4 ft. long and 2 ft. deep. For a standard-gauge ditcher wider at top than bottom, say 4 ft. wide at top, 3 ft. at bottom, 5 ft. long, and 2½ ft. deep.

In operating, the plow is drawn through the cut at such depth as the nature of the material will permit, after which the scrapers are thrown outward from the car, and the loading chains hooked to the bails; the scrapers are then drawn forward until filled. Then the car is secured to the track by the means of dogs, and power is applied to the hoisting chains which turn the scrapers over and on the car. The car is then ready to be moved to the dump. The lid or cover of the scraper when loading becomes the bottom when turned on to the car, and is hinged and latched so as to be easily and effectively dumped. In excavating new cuts the track is thrown from side to side as each cut is taken out until the cut is finished. The strain of drawing plows and scrapers through the earth is directly from the power, so that there is no strain on the car or tendency to throw it from the track. An end-gate for the excavator is provided, which revolves on the side-bar which connects the scraper side-arms. It is turned down by hand after the scraper is loaded, which prevents the spilling of earth on the way to the dump.

Eight men will be needed for operating these excavators and plows. In ordinary materials, with steam power, they will take out 500 cubic yards of earth per day. These cars have no expensive or complicated parts, and can be repaired by an ordinary blacksmith.

This plow and scraper are the invention of Mr. Frank Nearing, C. E., Tarrytown, N. Y., from whom further particulars may be obtained.

Locomotives.

THE New Haven shops of the New York, New Haven & Hartford Railroad recently turned out a new mogul freight engine for the road.

THE Baldwin Locomotive Works in Philadelphia have received from the Northern Pacific Company an order for 82 locomotives, probably the largest order of the kind ever placed at one time.

THE Valley Railroad Company is now testing practically the use of oil as fuel for locomotives on an engine which is in use shifting in the yard at Cleveland, O. Other engines are to be fitted up shortly.

THE Brooks Locomotive Works, Dunkirk, N. Y., have an order for 18 mogul engines for the Lake Shore & Michigan Southern road.

THE Brooks Locomotive Works at Dunkirk, N. Y., have recently completed 10 heavy consolidation engines for the New York, Pennsylvania & Ohio road. The cylinders of these engines are 20 × 24 in., and the driving-wheels have 44 in. centers. The boiler is 60 in. diameter at the smallest ring and contains 240 flues 2 in. diameter and 11 ft. 6 in. long. The driving-wheel base is 15 ft. 2 in., and the total wheel base 23 ft. 7 in. The weight in working order is 113,500 lbs. on drivers, total 128,000 lbs. The tender holds 3,600 gallons and weighs empty 33,500 lbs. The engines have straight stacks and extension smoke-boxes, and the American steam brake on all the drivers.

THE Portland Company in Portland, Me., is building several locomotives for the Boston & Maine Railroad. Three have already been delivered.

Cars.

THE car works of Pardee, Snyder & Company, Watsontown, Pa., have received an order for 200 box cars for the Pennsylvania Railroad.

THE Harrisburg Car Manufacturing Company, Harrisburg, Pa., is building 100 tank cars for the Standard Oil Company.

THE Lebanon Manufacturing Company, Lebanon, Pa., is building a number of box cars for the Pennsylvania Railroad.

THE Lafayette Car Works, Lafayette, Ind., are building 50 furniture and 100 box cars for the Northern Pacific Railroad.

THE Carlisle Manufacturing Company, Carlisle, Pa., has a large order for box cars for the Pennsylvania Railroad.

THE Barney & Smith Manufacturing Company, Dayton, O., has an order for 400 box cars for the Northern Pacific Railroad.

THE Jackson & Woodin Manufacturing Company, Berwick, Pa., is building 200 box cars for the Pennsylvania Railroad.

THE Fitchburg Railroad shops at Charlestown, Mass., recently finished 50 stock cars, and have begun work on 400 box cars. All these cars are equipped with the Westinghouse brake.

THE car works of Murray, Dougal & Company, Milton, Pa., are at work on a lot of box cars for the Pennsylvania Railroad.

THE Pennsylvania Railroad shops at Altoona are just now at work on an order for 700 box cars for the road.

THE Dunham Manufacturing Company has recently filled orders for doors for over 2,000 cars, for different roads, including 75 to go to South America.

THE Boyden Power Brake Company has been organized in Baltimore, and will soon secure land and begin the erection of large works for the manufacture of the brakes, which are the invention of Mr. George A. Boyden, of Baltimore. The brake has been successfully tested on the Baltimore & Ohio Railroad.

THE Pullman Car Works, Pullman, Ill., have taken a contract to build 21 passenger cars for the Northern Pacific Railroad.

THE Minnesota Car Company has been organized to build a foundry and car works at Duluth, Minn. It is proposed to build a rolling mill also.

THE Dunham Manufacturing Company, Boston, is increasing its capacity for making its pressed steel stake-pockets for cars, owing to large orders for them. The company is also preparing to meet a large demand for the Servis tie-plate, which has been submitted to severe tests with success.

THE Chicago, Burlington & Quincy shops at Aurora, Ill., are building 12 new passenger cars 54 ft. long and 9 ft. 8 in. wide outside. The inside finish is antique oak, worked into very tasteful form, the carving being neat and artistic. The head linings are maroon colored, very rich looking. Adams and Westlake No. 91 lamps of 65 candle-power are used for lighting. The upper-deck lights are blue glass. There are lavatories at each end of the car, one for men, the other for women. At one end of the car there is a closet for holding small baggage belonging to passengers. The cars are carried on four-wheel trucks having 42½-in. Arbel wrought-iron spoke wheels with steel tires. The outside of the cars is painted Tuscan red, a new departure for the company's passenger rolling stock.

THE Elliott Car Works in Gadsden, Ala., are filling orders for coal and flat cars for the Alabama Great Southern and the New Orleans & Northeastern roads.

THE Anniston (Ala.) shops of the United States Rolling Stock Company are at work on a large order for ore cars for the Alabama Great Southern Railroad.

THE Terre Haute Car Company, Terre Haute, Ind., is building 200 box cars for the Cincinnati, Sandusky & Cleveland road.

Manufacturing Notes.

THE firm of T. William Harris & Company, 44 Broadway, New York, have been awarded the contract for extending the gas works at Dobbs Ferry and Hastings, N. Y. New pipes will be laid at both places.

THE Union Indurated Fiber Company, of New York, is now manufacturing pipes or conduits of its indurated fiber for use in laying underground electric wires. Recently 50,000 ft. of this pipe were laid in Philadelphia.

THE Chicago Steel Rail Company has recently been incorporated in Chicago by Samuel W. Adams, John Good, and others.

THE Hoyt Frog & Crossing Company has been incorporated in Chicago by Frederick J. Hoyt, William E. Wolff, and others.

THE Martin Anti-Fire Car Heater Company, Dunkirk, N. Y., has recently closed contracts to put its heating system in 80 cars for the Wagner Company, and to equip all the passenger cars of the Rome, Watertown & Ogdensburg Railroad.

THE Korting Gas Engine Company has removed its factory and office to new and larger quarters at No. 431 Greenwich Street, New York.

THE Harvey Steel Company has begun to erect works in Newark, N. J., for the manufacture of steel by a new process invented by Hayward A. Harvey.

HOFFMAN & BATES, Portland, Ore., have contracted to build a bridge 270 ft. span at Fall City, Wash. Terr., across the Snoqualmie River.

THE Ansonia Brass & Copper Company, Ansonia, Conn., has begun the manufacture of the Tobin bronze, a new alloy invented by Passed Assistant Engineer John A. Tobin, U.S.N. It is claimed that this alloy is remarkable for its tensile strength, rigidity, and toughness, and that its density and great resistance to the action of salt water make it specially suitable for marine purposes.

THE Industrial Works, Bay City, Mich., have just completed a pile-driver of unusual size for the Denver & Rio Grande road, and a heavy wrecking car for the New York, Lake Erie & Western Railroad.

THE Standard Underground Cable Company, of Pittsburgh, has closed two large contracts for electric-light cables for Chicago. One contract was made with J. P. Barrett, Superintendent of the Electrical Department of Chicago, for five miles of electric light cable, which will connect with the municipal light station of that city and distribute the current to 65 arc lamps, each having a lighting capacity of 2,000 candle-power. The other contract is to furnish 50,000 ft. of cable for the Consumers' Electric Cable Company, of the West Side, Chicago. The incandescent electric light will be used in the latter place.

Luttgens' Variable Exhaust Damper.

THE accompanying engraving represents a locomotive smoke-stack fitted with the variable exhaust damper invented by Mr. H. A. Luttgens, of Paterson, N. J., which has been in use for four years past, and is now applied to over 100 engines on the New York, New Haven & Hartford, the New York, Susquehanna & Western, the Long Island, and many other roads. This damper is on the double-ender engine of the New York &

Northern Railroad, which was illustrated and described in the October number of the JOURNAL.

In this damper the base of the chimney is made with a number of openings, through which air can be admitted to the stack. On top of these is a circular valve or cover, with corresponding openings, and this can be moved by means of links and a lever operated by a rod from the cab. The engineer can thus admit air, increasing or diminishing the quantity, or shutting it off at will, regulating the draft as required.

This damper has worked well in practice, and it is claimed that it does away with the necessity of opening the fire-door to admit cold air, saves the flues very much, and also secures a considerable saving in fuel.

Marine Engineering.

THE Harlan & Hollingsworth Company in Wilmington, Del., have the contract for a new twin-screw iron steamboat for the New Jersey Central Railroad. The boat is to run between New York and Sandy Hook on the company's Long Branch line, and will be very much like the *Monmouth* which was put on that line last season.

THE William Cramp & Sons Ship & Engine Company recently launched from its yard in Philadelphia a new steel steamship for the Clyde Line. This ship, which is named the *Iroquois*, is

293 ft. long, 46 ft. beam, and 28½ ft. depth of hold, and will carry 2,900 tons on a draft of 15 ft. Her engines will be of the triple-expansion type, with cylinders 23, 36, and 60 in. diameter by 36 in. stroke. There will be four return tubular boilers 11 ft. diameter by 12 ft. long, carrying a steam pressure of 160 lbs. There will be accommodations for 75 first-class passengers. The steamer will be schooner rigged.

Electric Street Railroads.

THE Lynndale street line in Minneapolis, Minn., 3½ miles long, is to be run by electricity. Sprague motors will be used on the cars; the power will be furnished from the Edison electric light station.

THE Thomson-Houston Electric Company has contracted to equip the Cambridge & Arlington Branch of the West End Street Railroad Company in Boston with electric motors. Power will be furnished through an overhead conductor.

THE People's Street Railroad Company will equip its lines in Scranton, Pa., with electric motors. This company has four lines, about 12 miles in all, and 20 cars. The Sprague motor will be used, with overhead conductors.

THE Brookline Branch of the West End Street Railroad Company's lines in Boston is to be equipped with electric cars. The Bentley-Knight conduit system is to be used in the more crowded streets, and an overhead wire on the suburban section. Sprague motors will be used on the cars.

Bridges.

THE Wheeling Union Railroad Company proposes to build a new bridge over the Ohio River at Wheeling, W. Va. It will be a double-track railroad bridge 90 ft. above low water and 2,100 ft. long, with a channel span 535 ft. long. The cost is estimated at $2,000,000.

THE new Central Viaduct in Cleveland, O., which is now approaching completion, has been built by the King Iron Bridge & Manufacturing Company. This viaduct crosses the Cuyahoga River and the adjoining flats. The total length of the bridge is 2,838 ft., and the roadway is 101 ft. above the river. The draw-span at the river crossing is 239 ft. long.

THE Lane Brothers Bridge & Construction Company has been organized at Newark, O., and has taken the business of the former firm of Lane Brothers, bridge-builders and contractors. The change is made in consequence of the death of William H. Lane of the old firm.

Proceedings of Societies.

Master Mechanics' Association.

THE following notice has been issued by the Secretary:

"Mr. J. H. Setchel, President of this Association, has removed to Cuba, N. Y., and that will in future be his address.

"Mr. Angus Sinclair, Secretary, has removed from Chicago, and his office address in future will be, Morse Building, 140 Nassau Street, New York."

Franklin Institute.

THE Franklin Institute, Philadelphia, has issued the announcements for its usual winter course of lectures. Those for November are as follows:

November 5: Feasibility of Underground Railroads in Philadelphia; Professor Lewis M. Haupt, University of Pennsylvania.

November 12: Long Distance Transmission of Power by Electricity; Frank J. Sprague, of New York.

November 19: Some American Contributions to Meteorology; Professor William M. Davis, Harvard University.

November 26: Pig Iron; John Birkinbine, Philadelphia.

New England Railroad Club.

A REGULAR meeting was held in Boston, October 10, President Lauder in the chair.

Mr. George Richards read a paper on Quick Journeys and Fast Running, giving some account of fast trains in this country and abroad, and showing what was needed on a railroad to secure fast time with safety.

This paper was discussed by the President, Messrs. Sinclair, Adams, Davidson, Folsom, Brown, Snow and others.

American Society of Civil Engineers.

A REGULAR meeting of the American Society of Civil Engineers was held October 3, at the Society's House in New York.

A paper was read by John A. Bensel on the New Transfer Bridge, Harsimus Cove, Jersey City, which was followed by a brief discussion.

A paper by George W. Cooley on the Permanence of Bench Marks on Trees, giving the results of many observations, was read by the Secretary and briefly discussed.

A written discussion by C. P. E. Burgwyn of the paper by Colonel William P. Craighill on the Improvement of Several Rivers of the Atlantic Coast was also read by the Secretary. It referred mainly to the work done on the James River and to the improvement effected by the Dutch Gap Cut-off.

The following gentlemen were elected:

Members: William Barker Landreth, Schenectady, N. Y.; Charles Levings, Chicago, Ill.; Charles Abbott Locke, Nashville, Tenn.; Gouverneur Morris, Ardsley, N. Y.; George Thomas Nelles, Leavenworth, Kan.; Frank Chittenden Osborn, Pittsburgh, Pa.; Charles Francis Powell, U.S.A., St. Louis, Mo.; Nathaniel Edwards Russell, Lansingburg, N. Y.; Isaac Austin Smith, Lebanon, Ill.; Linton Waddell Stubbs, Monroe, La.

Juniors: Toragoro Kondo, Kansas City, Mo.; Frank Parsons Lant, Marion, N. C.; Thomas Kennard Thomson, Pencoyd, Pa.

A REGULAR meeting was held at the Society's House in New York, October 17. The Nominating Committee presented a ticket to be voted for at the annual meeting, headed by Mr. M. J. Becker, of Pittsburgh, as President. The Secretary presented a blue-print of one of the pumping engines at the new sewerage works in Boston and several photographs of the Poughkeepsie Bridge.

A paper was read on the Construction of the Sweetwater Dam, San Diego County, Cal., by James D. Schuyler, describing an important masonry dam built to form a large storage reservoir for supplying water for San Diego and also for irrigating purposes. This was discussed by Messrs. Fteley, Francis, Wegmann, Buck, Adams, Croes, Davis, Hunt, Comstock and Cooper. The discussion turned largely on the merits of the arch form for masonry dams, although something was also said of leaks in dams.

Boston Society of Civil Engineers.

THE regular meeting was held September 19, President Fitzgerald in the chair; 48 members and nine visitors present.

Messrs. Louville Curtis and William M. Scanlan were elected members and two names proposed for membership.

Votes of thanks were passed to the various persons who had extended courtesies on the occasion of the Society's visit to Providence and Newport.

A committee consisting of Messrs. J. E. Cheney, D. H. Andrews, and E. S. Shaw was appointed to consider the question of the Proper Inspection of Highway Bridges.

Professor Dwight Porter, of the Institute of Technology, read a paper on the Removal of Roof Water, which was fully discussed by the members present.

Mr. J. Pickering Putnam, Architect of Boston, was introduced, and read a paper on House Drainage, giving the results of his experiments upon the ventilation of traps. The paper was discussed by members of the Society and by Colonel George E. Waring, Jr., of Newport.

Engineers' Club of Philadelphia.

THE first regular meeting of the season was held at the Club's House in Philadelphia, October 6, President Joseph M. Wilson in the chair.

Mr. Frederick Stamm presented a paper on Chimneys for Horizontal Tubular Boilers. The Author discussed the subject of chimney draft under various conditions, and presented formulæ for area of flue and height of stack, with examples.

Mr. H. W. Spangler presented a paper on Leaky Pistons and Indicator Cards.

Mr. Frank Cooper read a paper upon the Economics of Momentum Grades, with Especial Reference to Tributary and Suburban Railways. The object of this paper was to outline a method by which an approximate idea may be formed of the relative effects produced by a succession of sags 26.4 ft. deep, in comparison with a dead-level line of railway, taking various speeds of trains, with stops located from 1 to 10 miles apart. Having determined under fair conditions the energy thus saved, and knowing the average percentage of cost of fuel per train-mile to operating expenses, and to net earnings according to the census of 1880, then applying the percentage of energy saved to this cost of fuel, an estimate may be formed of the value of the principle.

The Secretary presented, for Mr. Robert A. Cummings, a Table of Square Feet in Decimals of an Acre, for the *Reference Book*.

The Secretary made sundry minor announcements.

Engineers' Society of Western Pennsylvania.

At the regular meeting in Pittsburgh, September 18, Messrs. Thomas F. Cole, Leonard J. Holt, A. C. Linkenheimer, and John G. Park were elected members.

The discussion of Mr. Koch's paper on Open-Hearth Steel was continued by Mr. Hibbard and Professor Phillips.

Mr. Edmund G. Aikman read a paper on the Janney Coupler. This was discussed at considerable length by Messrs. M. C. Becker, E. B. Taylor, C. B. Price, Hibbard, and Roberts. The discussion was continued to the next meeting.

Engineers' Club of Cincinnati.

The regular monthly meeting was held in Cincinnati, September 5. Two applicants were elected active members, increasing the Club membership to 64.

A standing committee composed of Messrs. G. Bouscaren, M. W. Venable, and E. A. Hermann was appointed to co-operate with other clubs in securing State Inspection of Highway and Railway Bridges.

Mr. Oswald Dietz discussed in a very interesting paper the application of several simple algebraic formulæ to numbers of any magnitude, by which processes of addition, subtraction, multiplication, and division can be performed mentally with great rapidity.

Civil Engineers' Society of St. Paul.

The first regular meeting of the season was held in St. Paul, September 3, Vice-President Morrison in the chair. Mr. F. W. McCoy was elected Treasurer in place of C. L. Annan, resigned.

Mr. F. W. McCoy read a paper upon Street Improvements in St. Paul, including a statement of the amounts of earth, macadam, and paved streets improved in St. Paul and the cost for the past two years

Mr. J. D. Estabrook, Superintendent of Parks in St. Paul, followed with an interesting paper upon the Changes of Level in the Northwestern Lakes, illustrated by maps and charts giving the variations in the Great Lakes and others, and comparisons with the rainfall for the last 25 years. This is a subject of especial local interest in reference to Lake Como.

The regular meeting was held in St. Paul, Minn., October 1. J. D. White, City Engineer of Fargo, Dak., was elected a member.

The form of contract for buildings, as recommended by the National Association of Builders, was submitted, and laid over until the Secretary should correspond with the National Association in regard to the matter.

President Loweth read a paper on Tests of Angle-bars. These tests were made by him in 1887, and tend to throw some light on the effect of rivets and rivet-holes in such members.

Mr. A. Münster read a paper, illustrated by photographic views, on the Highways and Railroads of Norway, showing some striking examples of location and construction.

Engineers' Club of Kansas City.

At the regular meeting in Kansas City, October 1, Messrs. John M. Waller, S. H. Yonge, and H. H. Filley were chosen members, and S. P. Maybach an associate member. It was announced that rooms for a library and for meetings had been secured, and that papers had been promised for nearly every meeting till March. Several additions to the library were reported.

A letter from Mr. C. R. Taylor, of Philadelphia, was read, describing a new patent for street pavements.

Mr. A. J. Mason read a paper entitled the Complete Sewerage of Kansas City, which was discussed by Messrs. C. W. Pearsons, Gillham, Knight, Kiersted, and Allen.

General Time Convention.

The fall meeting was held in New York, October 10, with about 75 members in attendance. The date fixed for the general change of time of through trains was November 11.

The Committee on Car Mileage Rates presented a long report, embodying statements of the results obtained from the use of the mixed mileage and per diem rate on a number of different roads. The conclusion reached was that where this system had been tried there had been a considerable increase in the average mileage of the freight cars, showing a gain of nearly 28 per cent. The Committee recommended the continuation and general adoption of the system, and also an increase of demurrage charges from 50 cents to $1 per day. They further recommended that the distribution and movement of cars be placed under control of the transportation department entirely, and that complete statements and daily reports of car movements be adopted. In relation to passenger equipment a rate of $5 per day for passenger and $3 for baggage cars were recommended.

This report brought out a long discussion, at the close of which resolutions were adopted expressing approval of the general plan of mixed mileage and per diem charge for the use of cars, but referring the whole matter back to the Committee with instructions to gather more information, and to recommend the best method of putting the plan into general execution. The rates for passenger equipment were adopted; also the recommendations in relation to the distribution of cars.

The Committee on Train Rules reported that the uniform code adopted by the Convention is now in use on about 30,000 miles of railroad, and enough other companies have announced their intention to adopt it to make the total number of miles committed to the use of the code about 49,000, operated by 79 different companies. The report recommended that standard diagrams be prepared showing the position of flag and lamp signals on engines and cars according to the standard rules, and the Secretary was instructed to have such diagrams prepared.

The Committee on Transmission of Uniform Time announced that arrangements had been made with the United States Naval Observatory at Washington and the Western Union Telegraph Company, by which standard time would be transmitted free once each day to any road desiring it.

The Executive Committee reported a number of amendments to the rules of order, and also recommended that the name of the organization be changed from the General Time Convention to the American Railroad Association. Under the rules these recommendations will come up for discussion at the spring meeting.

American Institute of Mining Engineers.

The 52d meeting began in Buffalo, N. Y., on Tuesday, October 2. At the opening an address of welcome was made by Dr. Julius Pohlmann, to which the President replied. The President then made an address advocating improvement in existing mining schools and urging that better opportunities be given to students for practice and work. Dr. R. W. Raymond then read a paper on an Ancient Gold Breast-plate found in Central America.

On Wednesday morning the members went to Dunkirk, where they visited the Brooks Locomotive Works and other manufacturing establishments. In the evening a business session was held, and papers were read on the use of Asphalt, by Captain F. B. Greene; on Geysers, by Dr. R. W. Raymond, and on the Life History of Niagara Falls, by Dr. Julius Pohlmann.

On Thursday the members employed their time visiting various points of interest in the neighborhood of Buffalo; in the evening there was the annual dinner of the Institute at the Niagara Hotel.

On Friday two sessions were held. In the morning papers were read on Steel Rails, by Robert W. Hunt, and on Electrical Transmission of Power, by R. P. Rothwell. At the afternoon session a paper on Forestry and Mining was read by B. E. Fer-

now, of the Agricultural Bureau at Washington. A large number of papers were presented by title, according to the usual custom, and will appear in the proceedings of the Institute.

This closed the actual work of the meeting, but the members remained together until Saturday, occupying Friday with visits to the Holly Works and the Cowles Electric Works at Lockport, and Saturday with an excursion to the salt mines of the Retsof Company.

Over 50 new members joined the Institute at this meeting. The spring meeting will be held in New York in February.

American Society of Mechanical Engineers.

THE ninth annual meeting began in Scranton, Pa., October 15. At the opening session an address of welcome by Colonel J. A. Price was responded to by Vice-President C. J. H. Woodbury. Papers were then read on Distribution of Internal Friction of Engines and on Variable Load, Internal Friction and Engine Speed and Work, by Professor R. H. Thurston, and on Friction of Piston Packing Rings in Steam Cylinders, by T. E. Denton.

On the second day, at the morning session, the report of the Council was first presented, and directed attention among other things to the invitation extended by the British Institution of Mechanical Engineers to hold a joint meeting at London next year, and also to visit Paris, where a joint meeting with the British Iron & Steel Institute is in prospect. Messrs. Wiley and Hutton were appointed a committee to give the matter further consideration. Thirty new members, four associates and seven juniors were elected, bringing the total membership of the society up to 903.

Reports were also presented by the Secretary for the Library and Finance committees, the committees on Uniform Tests, Standard Flanges, and Uniformity of Duty Trials of Pumping Engines. Progress in the work of all was reported, and the committees themselves were continued. The report of the tellers, which was then presented, showed that the following officers had been elected for the ensuing year: President, Henry R. Towne; Vice-Presidents, William Kent, Thomas J. Borden and C. B. Richards; Managers, George M. Bond, F. H. Ball and William Forsyth; Treasurer, W. H. Wiley.

A resolution to reduce the number of meetings to one each year was laid on the table after a long discussion.

Papers were read on the Use of Compound Engines for Manufacturing Purposes, by Charles T. Main; on Flow of Steam in a Tube, and on a Simple Calorimeter, by C. H. Peabody.

The afternoon was devoted to a visit to the works of the Lackawanna Coal & Iron Company, and the evening to a reception given by the Scranton Board of Trade.

At the morning session on the third day papers were read on a System of Worm Gearing of Diametral Pitch, by S. W. Powell and W. L. Cheney; Improved Method of Finding Diameters of Cone and Step Pulleys, by C. A. Smith; Strength of Cast Iron, by Professor Gaetano Lanza; Identification of Dry Steam, by J. E. Denton; Cost of Power in Non-condensing Steam Engines, by Charles E. Emery; Counterbalancing the Reciprocating Parts of Locomotives, by Professor Lanza. Topical discussions on Steel Phenomena closed the session.

The afternoon was devoted to excursions to the works of the Dickson Manufacturing Company, the Pine Brook Colliery, the Boies Steel Car Wheel Works, and the works of the Suburban Electric Railroad Company. In the evening another professional session was held, at which special attention was again given to the discussion of Steel Phenomena.

The fourth day was devoted to an excursion to Hawley, Honesdale and over the gravity railroad to Carbondale.

The concluding business session was held on the morning of the fifth day, October 19, at which several papers were read. The usual routine work was attended to and the meeting adjourned, the members dispersing in the afternoon.

Master Car-Builders' Association.

THE following circular has been issued by the Secretary under date of October 12:

"The following questions have been submitted to a letter ballot of the members, with the results given after each question. One ballot was sent without a signature, and therefore was not counted.

"1. To substitute the following for the present standard specification for RUNNING BOARDS: The ends of the running boards of box-cars to be made to project over the ends of the cars, so that the *minimum* distance between the ends of those on adjoining cars will not be over 12 in.; and that the running boards be made not less than 2 ft. wide, and made of three boards 7 by 1 in. The projecting ends to be supported on two brackets, at each end of the car, made of ⅜ by 1¼-in. iron, with a hard wood cleat 3 by 1 in. on upper ends, fastened with one ⅜-in. bolt and nut in each bracket. The lower end of each bracket to be fastened to the end of the car with two ½-in. bolts and nuts.

"The vote on this substitute for the old standard was 329 'yes' and 84 'no.' The substitute is therefore adopted as a standard of the Association.

"2. To substitute the following for the present standard specification for LADDERS: Each end of every box and stock car to have a ladder attached to it next to the corner which is on the left-hand side when a person is facing the end of the car. The sides of the ladder to be made of two pieces of hard wood 3½ in. wide by 1⅜ in. thick, each piece to be fastened with four ½-in. bolts and nuts to the end of the car, the narrow sides of these pieces to be fastened against the car. The distance between the strips to be 15 in. Each ladder to have not less than five steps on rounds made of ⅝-in. round iron; each step to be fastened to the ladder sides with a ½-in. bolt in each end. The lower round to have a guard or projection, to prevent men from slipping when swinging around the end of the car to get on the step. A hand-hold to be attached to the top of the car roof parallel with the ladder rounds 15 in. from the end of the roof. The hand-hold to be made of ⅝-in. round iron, and to be not less than 17 in. long from center to center of bolt-holes, and to be fastened to the car with two ½-in. lag screws.

"The vote on this substitute for the old standard was 261 'yes' and 171 'no.' The substitute is therefore defeated, not having two-thirds of the votes cast, as required by the constitution.

"3. To substitute the following for the present specification for standard STEPS: Two good substantial steps to be made of wrought iron of ½ by 1⅜ in. section to be fastened one to each side sill, next to the corner of the car to which the ladder is attached. The steps to be not less than 12 in. long, measured horizontally between the sides, and the tread to be not less than 8 in. below the bottom of the sill. The side of the step next to the corner of the car to be as near to the end of the car as is practicable. Each side of the step to be fastened to the sill with two ½-in. bolts and nuts. A hand-hold to be attached to the side of the car above each step—to be placed horizontally 2 ft. above the bottom of the sills. The hand-hold to be made of ⅝-in round iron, 2 ft. long in the clear between the ends; to have 2½ in. clear space between it and the sides of the car; to be fastened with one ½-in. lag screw in each end, screwed not less than 2 in. into the framing. Another handle of the same size, and fastened in the same way, to be attached horizontally to the end of the car the same distance above the sills, and on the opposite side of the ladder.

"The vote on this substitute for the old standard was 345 'yes' and 87 'no.' It is therefore adopted as a standard of the Association.

"4. To substitute the following for the present specification for standard BRAKE-SHAFTS: The brake-shaft to be placed on what is the left-hand corner of the car when a person is standing on the track facing the end of the car. The ratchet wheel and brake-pawl to be fastened to a suitable casting attached to the roof. A railing or guard to be attached to the end and the roof of the car around the brake-shaft. The center of the brake-shaft to be 20 in. from the middle of the car. The nuts on the ends of the brake-shafts to be secured by split spring cotters.

"The vote on this substitute for the old standard was 312 'yes' and 102 'no.' It is therefore adopted as a standard of the Association.

"5. To adopt the form and dimensions shown in fig. 3 [not given here] as a standard for axles for cars of 60,000 lbs. capacity.

"The vote on this proposed standard was 224 'yes' and 307 'no.' It is therefore defeated.

"6. To adopt the dimensions given in figures on figs. 4, 5 and 6 [not given here] as standards for stem, dead-blocks and carrier-irons of M. C. B. standard automatic car couplers.

"The vote on this proposed standard was 325 'yes' and 185 'no,' and it is therefore defeated."

Western Society of Engineers.

THE first regular meeting of the season was held in Chicago, October 10. After the routine business had been transacted, the Secretary presented written discussions of Mr. Wisner's paper upon Levels of the Lakes as Affected by the Proposed Lake Michigan and Mississippi Water-Way, from Professor L.

M. Haupt, Professor J. B. Johnson, and Messrs. Clemens Herschel, William P. Judson, Walter P. Rice, and D. F. Henry.

These papers were read and discussed, and the Secretary was authorized to compile the same with explanatory matter for publication. It was announced that other contributions were expected.

OBITUARY.

DENNISON RICHMOND, who died at Syracuse, N. Y., October 4, aged 46 years, had been for 25 years employed as an engineer on the New York State canals. For some years past he had been Engineer of the Middle Division, having charge of all maintenance and repairs.

GEORGE RUMFORD BALDWIN, who died at North Woburn, Mass., October 12, aged 90 years, was a well-known engineer many years ago. He built the Quebec water-works and the Charlestown water-works, designed the Boston marine railway, and took part in the original surveys for the Cape Cod Canal. He was connected at different times with many important works as active or consulting engineer.

JOHN GEORGE BRILL, who died in Philadelphia, September 22, aged 71 years, was born in Germany, but came to the United States when a young man. He began the manufacture of street cars in Philadelphia many years ago, in a small way, gradually increasing the size of his works as the business grew, and finally manufacturing all classes of cars. The firm, for many years J. G. Brill & Sons, was reorganized as the J. G. Brill Company some years ago.

WILLIAM MILLER, one of the oldest and best known iron manufacturers in the West, and Chairman of the Miller Forge Company, Limited, of Pittsburgh, died, September 21, in Allegheny, Pa. He was born in Scotland, and came to America in 1849, connecting himself with the West Point Foundry, at Cold Spring, on the Hudson River. In 1855 he returned to Scotland, but in 1858 settled in Pittsburgh, where he started the West Point Forge, afterward merged in the Duquesne Forge, and finally in the Miller Forge Company, whose extensive works are at Rankin Station, near Pittsburgh.

JAMES L. RANDOLPH, who died at his home near Baltimore, September 17, aged 72 years, received his early training under the late Benjamin H. Latrobe, and was on the Baltimore & Ohio Railroad all his active life. Some three years ago he gave up active work, and was made Consulting Engineer of the company. His work is well described in the following minute passed by the Board of Directors: "Mr. Randolph entered the service of this company in 1836 as Assistant Engineer, and aided in the location and construction of its main line from Harper's Ferry to Wheeling, W. Va. As Chief Engineer of the company he constructed the Washington County Railroad from Weverton to Hagerstown; the Metropolitan Branch from Point of Rocks to Washington; the Somerset & Cambria Railroad from Somerset to Johnstown, Pa.; the Chicago Division from Chicago Junction, O., to Chicago; the Ohio & Baltimore Short line; the Valley Railroad from Harrisonburg to Lexington; the Winchester & Strasburg Railroad; the Hempfield Railroad, and the two massive bridges across the Ohio River, the one between Parkersburg and Belpre and the other between Benwood Bellaire. His name is indissolubly linked with the great engineering works of the Baltimore & Ohio system, and they are striking monuments to his engineering skill and spotless integrity. In these important enterprises he displayed the highest qualities of a civil engineer. Beginning his labors when the railroads of the country were comparatively few, he was forced to deal with many problems which required, from their novelty and complexity, great ingenuity as well as technical skill for their solution. Some of Mr. Randolph's most prominent characteristics were his simplicity and modesty, vigorous commonsense, and strong grasp of the broad principles of engineering."

PERSONALS.

ARTHUR POU is now Chief Engineer of the new Alabama Midland Railroad.

C. A. MERRIAM is now General Superintendent of the San Antonio & Aransas Pass Railroad.

W. G. JOHNSON is now Chief Engineer of the Philadelphia & Atlantic City Railroad.

C. F. BLUE is now General Roadmaster of the Kansas City, Memphis & Birmingham Railroad.

E. L. DUDLEY is now Vice-President and General Superintendent of the St. Paul & Duluth Railroad.

CHIEF ENGINEER N. P. TOWNE, U.S.N., has been ordered to duty in the Bureau of Steam Navigation.

FRANK C. SMITH has resigned the position of Master Mechanic of the Peoria, Decatur & Evansville Railroad.

ANDREW BECKART is now Master Mechanic of the South & North Alabama Division of the Louisville & Nashville Railroad.

COMMANDER WILLIAM M. FOLGER, U.S.N., has been ordered to duty as Inspector of Ordnance at the Washington Navy Yard.

W. G. WILLIAMSON, late City Engineer of Montgomery, Ala., is now engaged in river surveys with the United States Engineer Corps.

JAMES B. HOGG is now Chief Engineer of the Port Townsend & Southern Railroad, with headquarters at Port Townsend, Wash. Terr.

G. W. ETTENGER, late with the Chesapeake & Ohio Railroad, is now Master Mechanic of the Iron Car Company, of New York.

THOMAS F. OAKES, for some time past Vice-President, succeeds Mr. Robert Harris as President of the Northern Pacific Company.

J. A. DROEGE has been appointed Master of Trains of the Atlanta Division of the East Tennessee, Virginia & Georgia Railroad.

J. H. SETCHEL, late Superintendent of the Brooks Locomotive Works, has accepted a position with the Martin Anti-Fire Car Heater Company.

A. P. TUCKER is now General Superintendent of the New York, Pennsylvania & Ohio Railroad. He was recently on the Michigan Central.

WILLIAM PATTERSON has been appointed General Car Inspector for the lines included in the Southern Pacific Company's Pacific System.

O. F. NICHOLS, recently with the Suburban Rapid Transit road, has been appointed Chief Engineer of the Brooklyn Union Elevated Railroad.

CAPTAIN DAVID A. LYLE, Ordnance Department, U.S.A., has been detailed for duty in connection with the U. S. Commission to the Paris Exposition of 1889.

H. C. POTTER, for many years General Manager of the Flint & Père Marquette Railroad, has resigned that position and has gone to Europe for a long vacation.

ROBERT HARRIS has retired from the position of President of the Northern Pacific Railroad Company. He continues a director and Chairman of the Board.

JAMES W. WAY has been appointed Chief Engineer of all the leased and operated lines of the Missouri Pacific Railroad Company, with office in St. Louis.

F. A. GIVEN is now Master Mechanic of the Huntington Division, and W. J. HALLER Master Mechanic of the Newport News Division of the Chesapeake & Ohio Railroad.

COLONEL ROGER JONES, U. S. A., has been appointed Inspector General of the Army, with the rank of Brigadier-General, in place of General Baird, retired from active service.

R. H. SOULE has, it is stated, been offered by the Secretary of the Navy the position of Superintendent of the new ordnance works now being constructed at the Washington Navy Yard. Mr. Soule has, however, declined the position.

GEORGE E. MERCHANT has resigned the position of General Manager of the Western New York & Pennsylvania Railroad, and is now President of the Rochester & Pittsburgh Coal & Iron Company.

J. F. O'BRIEN, who recently resigned the position of General Superintendent of the New York, Pennsylvania & Ohio Railroad, is now General Manager of the Mexican National Railway.

T. W. HEINTZELMAN is appointed Master Mechanic of the Oregon, Benicia and California Pacific divisions and branches of the Southern Pacific Company's Pacific System, having

charge of the Locomotive Works at Sacramento, with headquarters at the latter place.

C. C. WENTWORTH has been placed in charge as Chief Engineer of the construction of the West Virginia & Ironton Railroad, which is an extension of the Norfolk & Western across West Virginia.

WILSON BROTHERS & COMPANY, civil and consulting engineers and architects, have removed their offices from their former location to the new Drexel Building, corner Chestnut and Fifth streets, Philadelphia.

T. M. JACKSON, C. E., of Clarksburg, W. Va., has been appointed Professor of Civil and Mining Engineering in the West Virginia University, and will organize a new course of engineering in that Institution.

CHARLES S. CHURCHILL has been appointed Engineer of Maintenance of Way of the Norfolk & Western road, with headquarters at Roanoke, Va. He was recently in charge of the West Virginia extension of the road.

WILLIAM MCKENZIE is appointed Chief Engineer of Steamers and Master Mechanic of the Western, San Pablo and San Joaquin divisions and branches of the Southern Pacific Company's Pacific System, with headquarters at West Oakland, Cal.

T. WILLIAM HARRIS, of the firm of T. William Harris & Company, New York, has been elected Secretary of the Pomeroy, Middleport & Syracuse Street Railway Company. This road will extend from Middleport to Syracuse, O., a distance of over 10 miles, and will be built in a most thorough manner for a heavy freight and passenger business.

JOHN L. PORTER, who designed and constructed the iron-clad *Merrimac*, is now a ship carpenter in the Navy Yard at Norfolk. In 1844, it is claimed, the thought presented itself to Mr. Porter that a vessel could be so protected by iron plates that the shot and shells of the enemy's guns would have no effect upon her. He constructed a model embodying the idea, but never attempted to build the vessel he had designed. His proposition to make an iron-clad vessel that would float was hooted at. In 1861, after the Confederates had captured the Norfolk Navy Yard, he showed his model to Mr. Marshall Parks (who at that time had charge of the navy of North Carolina), who recognized the value of it and had a bill drafted by himself pass the Legislature providing for the building of the proposed iron-clad. Later the Confederate authorities adopted the plans and decided to use the hull of the old *Merrimac* for the purpose. Six months were required for the completion of the vessel, but great was the rejoicing of the Confederate Government when she smoothly glided into the Elizabeth River. The results are a matter of history.

NOTES AND NEWS.

Aluminium Manufacture in England.—For some time past experiments have been conducted in the neighborhood of London with the Castner process for manufacturing aluminium for use in the arts. The experiments have been so successful that a company has been organized and has nearly completed works at Oldbury, near Birmingham, England, for the production of aluminium and sodium on a commercial scale, under Mr. Castner's patents. These works will have a capacity of 1,500 lbs. of sodium and 500 lbs. of aluminium daily, and both metals will be produced, it is expected, at a price which will make it possible to use them extensively in making steel, bronze, and other alloys.

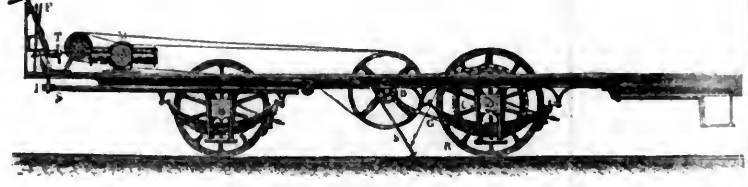
Costa Rica Railroads.—Mr. J. R. Wingfield, United States Consul at San José, Costa Rica, reports that the completed railroads in that country are:

From Port Limon to Corrillo, 70 miles; from Cartago to Alajuela, passing through San José and Heredia, 25 miles, and from Puntarenas to Esparta, 12 miles.

There are now being constructed 50 miles of new road from Cartago to a point near Siquires, on the Reveutazon River, to complete the connection with Port Limon. These roads are owned by the Costa Rica Railway Company (Limited) of London. To preserve the trade of California with Puntarenas, it is necessary that the road from Esparta be extended to the interior. Otherwise, when through connection is made with Port Limon, upon the completion of the missing link from Cartago, all trade will go by way of Port Limon. It is of the utmost importance to the trade interests of the United States to secure a charter from this Government to run a road from the valley of the San Carlos to San José. The proposed road connecting with the Nicaragua Canal would connect with steamers going both to ports on the Atlantic and on the Pacific. The aggregate exports and imports of Costa Rica last year were $11,000,000, of which the larger portion goes to and comes from Europe.

The Basic Steel Patents.—The *Bulletin* of the American Iron & Steel Association says: "The controversy between Mr. Jacob Reese, of Pittsburgh, and the Bessemer Steel Company, Limited, concerning the ownership of certain patents covering Mr. Reese's inventions in connection with the manufacture of steel by the basic process, has at last been finally disposed of by a verdict in favor of the company. On October 1 the Supreme Court of Pennsylvania, in an opinion by Justice Green, dismissed, with costs to appellant, the appeal of Mr. Reese in the case of the Bessemer Steel Company, Limited, against him to require him to deliver up certain patents for the basic process. There existed between the Bessemer Steel Company, Limited, and Mr. Reese contract relations evidenced by four distinct writings. The specific controversy was whether Mr. Reese was bound to transfer to the Bessemer Steel Company, Limited, all inventions, patents, and applications for patents in existence on September 5, 1879, the date of the principal contract. The Master in chancery decided that such inventions were included in the contract, but limited them to such as related only to the manufacture of steel into rails, ingots, and billets. The Allegheny County Court decreed that all patents were included, and that Mr. Reese must assign them to the Bessemer Steel Company, Limited, for the sum of $32,000. This opinion is now sustained."

Electric Cars in Paris.—An electric car is now in actual service in Paris, on the tramway running through the Avenue de la Grande-Armée. Power is furnished by a battery of 144 accumulators of the Faure-Sellon-Volckmar type, and the usual service is about six hours without recharging. The motor is of the Siemens type, and is carried on the front platform, the connection with the driving-axle being made by chain-belts, arranged as shown in the accompanying sketch. The motor runs at from 1,000 to 1,200 revolutions per minute; from the motor



shaft *M* the belt runs to the large pulley on the intermediate shaft *P*. This shaft carries two small pulleys, from which two chain-belts, *G*, run over two pulleys, *C*, on the driving-axle. The driving-wheels revolve independently of each other, and can be run at different speeds in passing around curves.

The weight of this car is about as follows:

Car	7,700 lbs.
Accumulators	3,300 "
Motor, pulleys, etc.	1,650 "
Passengers (full load)	7,700 "
Total	20,350 lbs.

The car has, like most of the Paris tram-cars, seats on the roof, and can carry 50 passengers when fully loaded.

A Remarkable Railroad.—In the French island of the La Reunion (Bourbon) there is a railroad line which is worthy of note, on account of the many difficulties which were overcome in its construction, arising from the mountainous nature of the island, the rapid and variable streams, the tropical climate, and the nature of the business which it has to carry. This road is of one meter gauge, and is altogether 78 miles in length. There are in this short distance four tunnels, the total length of which is over 6.84 miles, and also many deep cuts and high fills. There are more than 200 bridges and culverts of less than 32.8 ft. in length, and besides these there are 43 large bridges and viaducts having a total length of 8.04 miles. Included in these are three bridges of 328 ft. in length, one of 1,312 ft., and one of 1,640 ft., and a viaduct 431 ft. long and 82 ft. in height. In the original location of the road it was provided that there should be no curve of less than 262.4 ft. radius; in the final location adopted there are found in three places curves of 351 ft., eight of 410 ft., 12 of 492 ft., and a large number of 656 ft. radius. There is no grade over 2 per cent., but grades from $1\frac{1}{2}$ to 2 per cent. constitute a large part of the road.

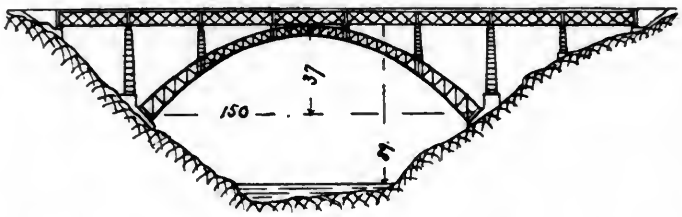
The superstructure is of steel rails of the Vignoles pattern, which were at first laid on prepared wooden ties; but most of these have been replaced by iron ties of the Livesey system, composed of two angle-irons with a plate prepared to receive

the chair and the bolts fastening the rail; these it is expected will last some time, and will obviate the trouble caused by the very rapid decay of the wooden ties in that tropical climate.

The locomotives used weigh 15 tons, and can haul a load of 50 tons. The passenger cars are 16½ ft. in length, 7½ ft. wide, and have a wheel-base of 6 ft. The freight cars are 13 ft. long, 7½ ft. wide, with wheel-base of 6½ ft.; they weigh 2.5 tons, and carry a load of 5 tons.

The cost of this road, including the tunnels, was over $48,000 per mile, and its construction occupied about three years.

The Paderno Viaduct.—The accompanying sketch gives an outline of a remarkable viaduct recently built over the river Adda near Paderno, Italy, on the new railroad from Seregno to Ponte St. Pietro. This viaduct crosses a deep and narrow valley, and the necessity of building lofty piers has been avoided by the adoption of an arch, as shown. The bridge is 304 meters (992 ft.) over all in length; of this 19 meters (62½ ft.) at either end are occupied by the masonry abutments, and the remaining distance is divided into eight spans of 33.25 meters (109 ft.) each, of lattice girder. These eight spans are supported by the abutments and by seven iron piers of varying height. Three of



these piers, as will be seen from the sketch, are founded directly upon the rocky banks of the river. The remaining four are carried on the elliptic arch which spans the gorge. This arch has a span of 150 meters (492 ft.) and a rise of 37 meters (123 ft.). The total height of the bridge, from the usual level of the river to the bottom of the lower chord, is 89.25 meters (293 ft.).

The bridge has two floors, the railroad track being carried on the lower chords of the girders, while above is an upper floor supporting the carriageway and sidewalks. The design was selected from a number submitted to the Ministry of Public Works by engineers and constructors, and was prepared by J. Rothlisberger, Engineer of the Savigliano Works in Piedmont. It is being constructed by those Works. The dimensions given on the sketch are in meters.

New Shops of the London & Southwestern Railway.—Owing to the increase of traffic and of rolling stock, the locomotive, carriage, and wagon works of the London & Southwestern Company at Nine Elms, near London, have of late been altered and enlarged by Mr. William Adams, the present Locomotive Superintendent. These works now cover 45 acres of ground, and give employment to between 2,000 and 2,500 men.

The locomotive department consists of a number of shops where the various details of the locomotives and tenders are prepared and finally erected into a complete engine and tender. The cylinder shop is provided with a useful overhead traveling crane. Here are also two fine vertical milling and drilling machines. The cylinder-boring machine is adapted for boring two cylinders at one time. The fitting shop is 118 ft. long and 58 ft. wide, and is arranged upon the most approved plan. The brass fitters' shop is 59 ft. long and 45 ft. wide. In this shop is made the white metal piston and valve-rod packing, which is a standard now with all new engines of the Southwestern Railway. The millwright shop is 85 ft. long by 58 ft. wide, and is fitted with all the modern machinery. In it are made the small machines used in the Nine Elms shops. In course of construction is a double-cylinder horizontal steam-engine for the saw-mill. It is intended to run at 140 revolutions per minute, and will drive on to the line-shaft by means of 10 ropes and will be capable of transmitting 350 indicated H. P.

In the machine shop, which is 300 ft. long by 57 ft. wide, all machines of one class are placed together. Screwing machines which are capable of screwing, with excellent finish, 800 copper stays in the course of a day, are found here. In the same shop are numerous small lathes and a massive crank-axle having four rests, all of which may be used at one time.

The erecting shop consists of two bays, each 500 ft. long by 57 ft. wide, which afford accommodation for 70 locomotives. Power is supplied to the small tools in this shop through hydraulic mains at a pressure of 1,500 lbs. per square inch. The boiler shop is 178 ft. long and 116 ft. wide, and is fitted up with the most approved appliances. In the hydraulic engine-house are fixed two pairs of engines which supply water at a pressure of 1,500 lbs. per square inch to an adjoining accumulator, from which all the hydraulic tools in the shop are worked. The smiths' shop contains 26 forges inclusive of bolt-makers' fires. Adjoining the iron foundry, which is served by two five-ton steam cranes, is the brass foundry, which is fitted with Fletcher's furnaces and the usual appliances. The carriage-shop building is 194 ft. long and 60 ft. wide. The running shed, which is capable of holding 60 engines, is 235 ft. wide by 180 ft. long. In this shed is one of Pooley's weighing machines. The carriage paint shop affords accommodation for painting between 60 and 70 coaches.

The London & Southwestern Company operates 850 miles of road; on its lines there are in use 550 locomotives, 3,000 passenger cars, and 8,000 freight cars.

Railroad Accidents in Missouri.—The report of the Missouri Railroad Commissioners for 1887 gives the following statement of casualties on the railroads of the State for the year:

	Killed.	Injured.	Total.
From causes beyond their own control:			
Passengers	2	25	27
Employés	22	96	118
Other persons	21	12	33
Total	45	133	178
From their own carelessness or negligence:			
Passengers	5	15	20
Employés	36	188	224
Others	76	88	164
Total	117	291	408
Total number of casualties:			
Passengers	7	40	47
Employés	58	284	342
Others	97	100	197
Total	162	424	586

The number of employés in railroad service in the State at the close of the year was 25,160.

Concerning safety appliances, the Commissioners speak in the report thus: "The subject of automatic couplers for freight cars has attracted much attention during the past two years, and in some States legislation has been enacted requiring that some approved forms of automatic coupler be adopted. The Master Car Builders of the country have recommended several couplers, from among a very large number submitted to them for consideration, and it seems probable that in the near future all new freight cars built, and all cars sent to shops for repairs, and whose condition will warrant it, will be provided with some approved form of automatic coupler. To attempt at once to apply a new system of couplers and train brakes to the entire equipment of the railroads of the country would entail a very large expense, and which perhaps would not seem reasonable to require. Still, the question of safety to employés and others is a very serious one, and which should be carefully considered, and hardly anything could be deemed unreasonable which would reduce to a minimum the risks to life and limb to which every employé in the train service of a railroad is daily exposed.

"It is doubtless true, that before legislation in regard to safety appliances could be effective, it would have to be general. No single State can effect the needed reforms, and as the question is now one of national importance, and attracting very general attention, it is probable that some steps will soon be taken by Congress in the needed direction. We do not think the time has arrived for legislative action in Missouri in regard to automatic couplers or train brakes, for the reason that up to this time the conclusions of the Master Car Builders and experts in train management are not sufficiently definite to enable the Legislature to act intelligently in the premises, excepting, perhaps, in a general way, but we hope the time may soon arrive when legislative action can be had which will result in the adoption of such appliances as will very largely reduce the present appalling loss of life and injuries to persons resulting from exposure to the many perils of railroad train service."

Tramways in Vienna.—All of the tramways of Vienna are upon the surface of the streets. As yet I have heard of no project for high, or elevated, or subterranean tramways. As regards the return made by the tramway company for the use of the streets of Vienna, I am informed by the Mayor of the city that under the original contract entered into between the company and the city, under date of March 7, 1868, the company was bound to pay 5 per cent. of its gross receipts. Subsequently an agreement was entered into fixing a sum in gross to be paid by the tramway, which sum amounted, in the year 1886, to 125,000 florins ($46,375). In April, 1887, the original contract was again amended, and the compensation to be paid to the city for the use of the streets by the tramway company was fixed at the annual sum of 2,220 florins per kilometer ($1,167 per mile), with

the proviso, however, that the compensation was in no event to be less than 125,000 florins per annum.

The main provisions of these contracts cover the following points:

The plans of the construction of the tramways to be subject to the approval of the Common Council, the Council reserving the right to order any changes it may deem expedient.

All lines of tramways to have double tracks, with a space of at least 11 ft. between the tracks and between track and sidewalk. In narrow streets, a single track, with switches.

The quality of the material of which the tramway is built is prescribed by the contract. No tramway can be opened to the public until its construction is approved by the competent municipal authorities.

Right of way to cross established tramways to be granted to new lines.

The tramway company is held to clean, keep in order, etc., 8 ft. of street for each track. The models for tramway cars to be submitted for the approval of the Common Council.

The company to employ a sufficient number of guards for the safety of the public and for the operation of the road. The instructions for these guards, as well as for the conductors and drivers, to be approved by the Common Council. The contract prescribes the fare and time-table, limits velocity, number of passengers for each car, etc.

The company is held to great care to avoid collisions with wagons, etc., passing upon the streets, and is made liable for all damages arising from such collisions. (The doctrine of contributory negligence seems to have been disregarded.)

New inventions and improvements in tramways to be adopted at request of Common Council. The franchise of the Tramway Company to present holders is not transferable without the consent of the Common Council, and is limited to 35 years.

For each seat of cars in use the company pays in advance 1 florin (37 cents) annually into the pauper fund.

The company is not entitled to claim damages for interference with its traffic by means of movements of troops, public feasts, etc.

At the termination of the franchise the municipality may elect to either take possession of the tramway or to cause its removal, and the restoring of the respective streets to their original condition at the cost of the company.

In the first case, the company must deliver the tracks to the city in good condition and without any compensation whatever. The stables, depots, etc., are to be transferred at their appraised value; but the municipality is not entitled to claim nor bound to accept the transfer of the means of transportation (*transportmittel;* cars).

The company is obliged to deposit as security for the proper observance of the conditions of the contract the sum of 300,000 florins ($111,300) in city securities. In case the company fails to fulfill any of the conditions of the contract, the Common Council reserves the right to declare any portion of the indemnity found forfeited in its own motive, and without any interference on the part of the judicial tribunals or administrative authorities.—*Report of U. S. Consul-General Edmund Jussen to State Department.*

A New Vibrating Engine.—There is being built in Portland, Me., an engine which is the invention of Mr. Lidback, which has quite a number of novel features. I have called it a vibrating engine to distinguish it from a rotary, as the driving apparatus turns through part of a circle. The piston consists of a hollow cylinder, having four wings on its outer side. The outer edges of these wings carry packing pieces, which bear against the inner surface of the steam cylinder proper. Between the wings rectangular plates extend inwardly from the steam cylinder, which are made to bear against the outside of the cylindrical part of the piston. Each wing of the piston is therefore between two of these plates, and moves backward and forward as the piston vibrates. Fig. 1 will give a fair idea of the arrangement of the parts. *A A* is the piston carrying the wings *B B B B*, each of which is packed by the rectangular piece *C* against the interior of the cylinder *D*. *E E E E* are the plates fitting into recesses in the cylinder *D*, and set up by set-screws, two of which are shown at *F F*. *H* is the valve chamber, and steam is admitted through the center of the piston. Ports are cut through the piston *A* at *G G*. Two ports, one for steam and one for exhaust, are in each corner, but one lies at one end and one at the other of the piston *A*. The valve used is represented in fig. 2. It consists of a cone-shaped piece of cast iron, *H*, having steam ports, *I*, and exhaust ports, *K*, cut in it. Steam is admitted through the pipe *L*, and passes through *I* into the opening in the piston and into the cylinder. The exhaust is taken through the port *K* into the exhaust pipe. With larger sizes separate valves are used, and do away with heating the exhaust from the live steam. The spindle supporting the piston passes through a long bearing, and carries on its end an arm to which the connecting rod is attached. The fly-wheel shaft is carried in the same casting, and is directly over the cylinder. It is driven directly by the connecting rod, and carries on it what is practically an eccentric for moving the valve. On the smaller sizes a throttling governor is used, but on larger sizes a shaft governor is fitted, which varies the point of cut-off. A 10 H.-P. engine, single cylinder, weighs about 600 pounds complete, while a 10 H.-P. compound weighs a little over 300 pounds.

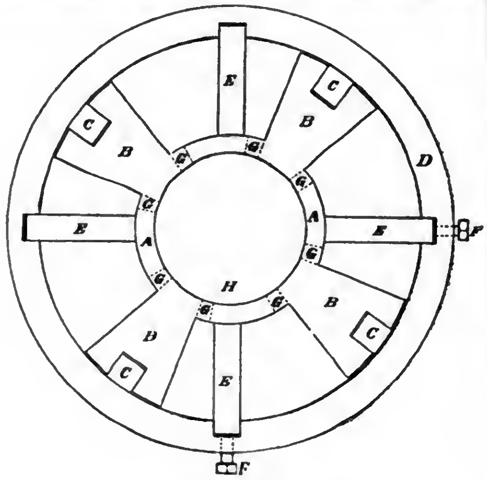


Fig. 1.

They can be run satisfactorily up to 1,000 revolutions, but generally are speeded at about 250. As the most important thing about an engine of this kind is the method of making the piston steam-tight, it is here more fully described. The rectangular pieces *C*, fig. 1, fit snugly into the recesses prepared for them, and as the steam is admitted on one side or the other, they are thrown against the opposite side and out against

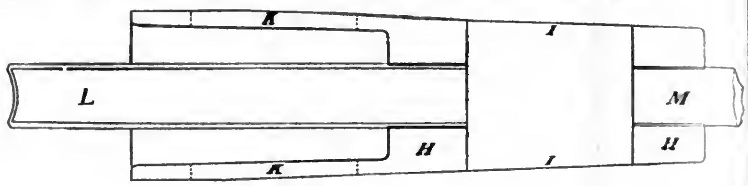


Fig. 2.

the cylinder by the steam pressure. The plates *E* are carefully finished along the inner edge and are set up from the outside. Steam is prevented from passing over the ends of the vanes or wings. At one end the piston-head is fitted against the end of the cylinder and piston by scraping, and the plates *E* are recessed into the head. The other end of the cylinder is made of a plate, which is recessed for the ends of the plates, allowing a movement

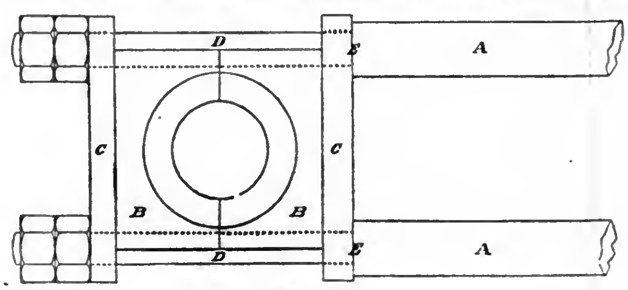


Fig. 3.

of the plate axially, and the piston and the plate present scraped surfaces to each other. This plate is set up by set-screws on the outside. The tightness depends, therefore, on the accuracy of the surfaces originally and the care with which it is set up. Engines have been built varying from one and one-half to 100 H. P., and have proved to be as tight as desired. The small floor space and head room required is not the least of the advantages of these engines. The connecting rods are quite ingenious and to me new. The brasses for each end are cast and fitted as shown in fig. 3. The two ends are alike. *B B* are the brasses; *C C* are two rectangular plates fitting over the rods *A A*, which are smaller at *D* than at *A*, having a shoulder at *E*. The brasses and plates are held on by the nuts, as shown. The brasses are prevented from moving, as the rods *D* are recessed into the sides of the brasses.—*H. W. S., in Journal of the Franklin Institute for October.*

THE RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

PUBLISHED MONTHLY AT No. 45 BROADWAY, NEW YORK.

M. N. FORNEY, ... Editor and Proprietor.
FREDERICK HOBART. . . . . Associate Editor.

Entered at the Post Office at New York City as Second-Class Mail Matter.

SUBSCRIPTION RATES.

Subscription, per annum, Postage prepaid $3 00
Subscription, per annum, Foreign Countries 3 50
Single copies 25

Remittances should be made by Express Money-Order, Draft, P. O. Money-Order or Registered Letter.

MR. J. HOWARD BARNARD, 7 Montgomery Avenue, San Francisco, Cal., is the authorized Western Agent for the JOURNAL.

MR. FREDERIC ALGAR, Nos. 11 and 12 Clements Lane, Lombard Street, London, E. C., England, is the authorized European Agent for the JOURNAL.

NEW YORK, DECEMBER, 1888.

SUBSCRIBERS who wish to have their volumes of the RAILROAD AND ENGINEERING JOURNAL for 1888 bound, can do so by sending their files to the office, No. 45 Broadway, New York, by mail or express, prepaid, and remitting the sum of $1.25. The bound volume will be returned to them, at their expense, without delay.

Should the file be incomplete, the missing number or numbers can be supplied at 25 cents each. The amount required to pay for them should be added to the remittance for binding.

Any special style of binding or any lettering desired may be ordered, for which only the actual extra cost will be charged.

The Title-Page and Index for the volume are a part of the December number. Subscribers who fail to receive them can have the omission supplied by sending a postal card to this office.

THERE will, apparently, be considerable progress made this winter in the introduction of steam-heating systems for cars. Nearly all the New York railroads will comply with the law, a few only having secured extensions of time from the Railroad Commission. The Boston & Albany, and several other New England railroads, are doing much in this direction, and attention has been called to it everywhere. The Chicago, Rock Island & Pacific has equipped its through trains between Omaha and Chicago, and other Western roads are also trying different systems.

The Railroad Commissions of Vermont and Minnesota have recommended legislation against car-stoves, and it is probable that some action will be taken in both States.

THE *Railway Age* reports a total of 5,790 miles of new railroad completed in the ten months of the current year up to the end of October. Taking into consideration the work now in hand this indicates a total of over 7,000 miles for the year.

The greatest mileage reported for any one State is in California, where 485 miles of track were laid. Kansas and Georgia follow closely, both having added over 400 miles. Kentucky and Illinois each report between 300 and 400 miles, while five others—Texas, Alabama, South Carolina, Colorado, and Washington Territory—had each over 200 miles.

In one respect this year's new railroad building differs from that of 1887; it has been made up chiefly of short lines. The 5,790 miles reported by the *Age* were on 280 different lines, the average length of the roads or additions being thus only a little over 20 miles.

The building this year has been mainly what this fact would indicate—short branches, feeders, and local lines. Many of these are additions to existing systems, but there has been very much less construction of competing and interfering lines than last year, and no roads that can be called main or trunk lines are now in progress.

WE are informed that applications for space for railroad machinery and appliances at the Paris Exposition of 1889 are not coming in rapidly to the United States Commission. Among those lately received are models of a rail-joint, a coupler, a turn-table, a train with ventilating apparatus, and a number of axles, steel-tired wheels, and street-car wheels.

Notwithstanding the fact that the great question in Paris just now is the new Metropolitan or city railroad, and the equipment which should be provided for it, no American locomotive builder has yet applied for space.

It is suggested to manufacturers that the Central and South American countries will be very largely represented at Paris, and that the Exposition will, therefore, offer a very good opportunity to reach the buyers of those countries at comparatively small cost.

Among the special features of the Exposition will be a "Retrospective Exposition of Industrial Work and Anthropological Sciences," which will virtually form a history of labor and the manifold applications of manual skill. The General Classification of this collection will comprise: 1. Anthropological and Ethnographical Sciences; 2. Liberal Arts; 3. Arts and Trades; 4. Means of Transportation; 5. Military Arts.

In each of these classes there will be displayed objects of all ages and all countries. Any resident of the United States who possesses objects that would add to the interest and value of this special exhibit can obtain all necessary information by applying to the Commission at its office, No. 1 Broadway, New York.

THE situation in Austria, in relation to the supply of railroad ties, seems to be very similar to that in this country. The supply of timber at present is sufficient, and the prices are not high, but the consumption is growing, and the destruction of timber for this purpose considerably exceeds the average annual growth of the forests. The price of metallic ties is still too high in that country to permit of their general substitution for wood, and in order to prevent too great a destruction of the forests, considerable attention has been paid to the preservation of ties by various processes.

The article on this subject, as published in another column, gives some interesting statistics to the life of ties, including the experience of a number of years, and the facts presented there are of sufficient importance to merit care-

ful study. One to which especial attention deserves to be called is that with the preserving treatment certain kinds of timber are available for railroad use, which without it would be worthless for this purpose. This fact has been urged upon the railroad companies by Mr. Fernow, Chief of the Forestry Division of the Department of Agriculture, who deserves thanks for his efforts in this direction.

SOME remarkable experiments have recently been made in England with armor-plates on a new plan, consisting of small plates of especially hard cast steel 3 in. thick fastened to a large plate of soft cast steel 7½ in. thick, the fastening being made by a special process.

The theory of this new plan is that should a shot strike one or more of the plates, the destruction would be confined to that particular small plate, and would prevent cracks from extending all over the plate. This was tested with projectiles of different kinds, and the theory was fully supported as far as the small plates were concerned. The method of holding them to the soft plate seemed to be imperfect, and several were detached in the test. The results, however, were sufficiently good to justify further experiments with this kind of composite armor-plate.

THE Army Ordnance report for the last year does not show very much progress, although more is hoped for during the current year, when the new gun factory will be completed, and better facilities provided for manufacturing guns. The tests of the 8-in. guns having been continued with favorable results, extended tests have also been made of the 5-in. and 7-in. rifled guns. The 12-in. breech-loading rifled gun, hooped and tubed, has made some advance, one having been built and sent to the proving grounds, while another is nearly ready, and the tests will proceed as fast as proper powder can be procured. The tests of the Department have been delayed by a short supply of powder, but this trouble it is hoped will not be experienced in the future.

THE present strength of our Navy and condition of the vessels is stated, in the annual report of Chief Naval Constructor Theodore D. Wilson, as follows: Five double-turreted monitors awaiting completion; two belted cruisers, preparing ways; 13 single-turreted monitors, in ordinary; 23 unarmored steel and iron vessels, four of which are in commission, 11 building, two repairing, five on station or undergoing repairs, and 11 iron and wood steam tugboats.

The payments made on account of vessels building under contract up to October 31 aggregate $3,266,195, and $885,349 was expended in the repair of ships, purchase of tools, etc. Five vessels were sold and condemned during the year.

The estimates for the current expenses of the year aggregate $936,452, while the appropriations were $868,952. In addition to these estimates $3,540,000 will be required to meet payments on account of hulls and outfits of new ships; but this sum has already been appropriated. The estimates include items of $50,000 each for the New York and Norfolk Navy Yards, to improve the plant. The Bureau recommends the immediate construction of experimental works, to cost $60,000, for use in the determination of the resistance and other qualities of ships by means of models.

The Mare Island Navy Yard is being fitted with a complete outfit of modern shipbuilding tools. The climate is such that it is perfectly practicable to conduct shipbuilding without the shelter of ship houses, which are expensive and do not favor rapidity of construction or excellence of workmanship on account of the darkness.

IN Chief Naval Constructor Wilson's report it is stated that the old sloop-of-war *Hartford* is likely to be condemned, unless the act passed by the House of Representatives authorizing her repair becomes a law.

Enough cannot be said against such a proceeding, for her past record has endeared her to the American people, and she should be preserved as a monument of her past achievements. It has been suggested that if she has outlived her usefulness as a cruiser she should be preserved as a receiving ship.

There can be no doubt that preserving vessels, which have been distinguished in naval history, has a favorable effect on the Navy, and a ship like the *Hartford* or the *Constitution*, in our own Navy, or Nelson's *Victory*, in the English Navy, will always be of interest not merely as a relic, but also as a stimulus to patriotism and to the *esprit du corps* of the Navy.

ADMIRAL PORTER, in his annual report to the Secretary of the Navy, while approving of the new class of steam vessels now being added to the Navy, still adheres to the belief that the best school for the education of seamen will be found in the old-fashioned sailing vessels, and he recommends that a few of this class be kept in service for the training of cadets and apprentices; steam vessels should be attached to the practice squadron, chiefly for exercise in gunnery. The Admiral says that the experience gained in the sailing vessels will be of service to officers on any sort of cruise or warship which has yet been devised, and that such experience can be gained in no other way.

The Admiral is an advocate of the Naval War College, and urges that the advantages derived from it are worth very much more than its cost to the Navy Department.

His opinion of torpedoes is apparently not very high; where they are planted in the bottom of a channel, he thinks that only a temporary stoppage would enable an attacking squadron to get rid of them. The movable torpedoes, such as the Whitehead and that class, have proved to be very uncertain in operation, and are not to be relied upon, while a properly equipped ship can defend itself from them with ease. The most formidable weapons of the kind are the dynamite or torpedo guns, firing shell loaded with high explosives, and he considers that this class of projectiles is capable of much greater development than it has heretofore received.

MR. A. S. ABELL, proprietor of the Batimore *Sun*, has set an excellent example by presenting a library of well-chosen books to the new cruiser *Baltimore*, for the use of its officers and crew. The gift in this place is made as an acknowledgment of the naming of the vessel after the city. Mr. Abell's example should be followed by others, as a library is always a welcome gift to a man-of-war. The *Boston*, the *Atlanta*, and other new vessels are open to proposals.

THE Russian Government is still considering the best methods of utilizing the Transcaspian Railroad as a commercial, as well as a military work. Preliminary exam-

inations have been made of the productive territory included in the Merv Oasis, and proposals for building a system of light railroads in that region are now under consideration.

THE recent manœuvres of the German army included the movement of large bodies of troops by rail, and the special service organized for this purpose was fully tested in practical working. The results of the test are reported as very good, and in several cases an entire division was moved in a surprisingly short space of time. The Transportation Corps and the "railroad regiments" attached to the different army corps had a full opportunity of showing their efficiency. In this respect, as in almost all others, the German army organization is exceedingly thorough and practical, and under it a temporary railroad can be quickly built or an existing line can be taken hold of and worked with little or no delay, no time being wasted in preparation.

A German railroad regiment is, in fact, a fully equipped body of railroad employés under military organization, its ranks including men for every department of a railroad fully trained to respective duties and ready to begin their work at any moment they may be needed.

IN a recent address before the British Institution, Sir C. W. Wilson refers to the effect which the Suez Canal has had on shipbuilding in that country. The immediate result was an increased activity, but the class of vessels built was inferior. The canal voyage to India requires a different ship from the Cape or ocean route, and those which have been built for that trade are not only smaller, but are lighter, less seaworthy, and not so strong as the older vessels which had to take the long ocean voyage, where storms were frequent and coaling stations few. The result is found in the fact that, with a great increase in tonnage, the proportion of ships which come up to the naval requirements and which would be available as cruisers in time of war has diminished.

This fact is not often so frankly stated as in the address referred to, but it has nevertheless been seen and appreciated by high authorities in England, who have not, however, been able to suggest anything which will change the tendency thus developed.

THE ENGLISH VERSUS THE AMERICAN SYSTEM OF RAILROAD CONSTRUCTION.

II.

AS a continuation of the article on this subject, published last month, the discussion of cars and other conveniences and facilities for traffic and travel by our two antipodal contemporaries will be reviewed in this article.

In discussing the merits of American cars, the *Jiji Shimpo* writer says that they are longer and wider than English cars, they have a passage-way through the whole train and a heating apparatus, while English cars have neither. He also says they oscillate less than English cars, and the latter are more dangerous in case of accident.

To this the *Mail* disputant replies, that the American passenger is obliged to squeeze past his neighbors, to their and his great inconvenience; that communication exists throughout American trains with the result that there is no peace nor quiet for an hour together, the center path being a highway for the numerous officials of the train, and for itinerant venders of books, fruit, candy, cigars, newspapers, and so forth, whereas in English cars "you escape the nuisance of perpetual ticket-punching, peddling, and nigger attendance;" that in an American car the passenger is compelled to sit upright in a chair, the back of which comes no higher than the shoulders, and gives no rest to the head, and it is not possible to stretch out one's legs or to recline, however empty the car may be, whereas in English cars you can rest your head against a high back; stretch your legs to their full extent, recline, as on a lounge, if the car be sufficiently unoccupied. American cars, he says, are well lighted and well warmed, but they are unbearably hot in winter, and owing to the terrible accidents caused by this system of heating laws had to be passed forbidding the use of stoves in cars. The windows, he continues, of English cars are about twice as large as those in American cars, and by reason of the method of the construction of the latter they do not present more than about half the areas of space for light and air afforded by the former internally, and in the hottest weather the traveler's head and face receive no breeze. The oscillation of American cars, he says, is so great that at 20 miles an hour one cannot safely walk without support, and that the weight per passenger of American cars is considerably greater than that of the British vehicle. Cars in England are now, he argues, largely lighted with gas, and in some instances with electricity.

Reading this discussion would probably have somewhat the same effect on a Japanese that many political disputes in this country have on the hearer—that is, he would conclude that neither candidate for favor is worthy of being selected. In such and other disputations there is, unfortunately, no known means of assigning a correct value to the facts and the reasons adduced on one side or the other. What is merely trivial may appear important, if presented in sonorous language, and with more or less personal accentuation. Thus it is true that American cars are longer and wider than English cars, and it is equally true that the seats in them are often crowded too close together, and that generally the seats in English cars are more roomy and more comfortable. But most English cars are without passage-ways through them, and therefore water-closets are impracticable, which would be an insurmountable objection to their use in this country, or in any other where there are long journeys. Now a passage-way should be not less than 22 in. wide, the seats, 38 in., the seat arms, 2 in., and the side of the car 6 in. thick, so that the total width would be 9 ft. 6 in. outside. To avoid frequent crossings from one car to another when passage-ways are used, their length must be increased, which makes the truck or bogie system essential. It is admitted that the good-natured American passenger is subjected to many annoyances from itinerant and local venders of sundry articles which generally he doesn't want, but the venders are merely incidental and not essential to the use of long cars and water-closets. It is also true that the backs of American car-seats generally "come no higher than the shoulders," and that they are often crowded too close together, but it would be very easy for our Japanese friends to get seats here with high backs, and to give more room between them. If "nigger attendance" is disagreeable banish the Ethiopian, and let the almond-eyed sons of the Orient attend their fellow-countrymen.

Heating apparatus is absolutely essential in cars for long journeys and in cold climates, and notwithstanding the

risk attending its use, as shown by some of the dreadful accidents which have occurred here, it is safe to say that many more people would die of sickness, consequent to exposure to cold, if no heating appliances were used for such journeys. The practicability of using steam heat on trains has also been shown, so that if heated cars are required the Japanese need have no fear of being roasted alive. It may be added that owing to the smaller number of steam-pipe couplings or stoves required on long than on short cars, there is less difficulty in heating the former than the latter.

With reference to the relative weight per passenger of English and American cars, there can be no doubt that the English cars have the least dead weight, but it is equally true that American cars are stronger than the others and will resist collisions unharmed, which would be totally destructive to the lighter vehicles. The additional dead weight is the price at which this strength and the convenience and comfort which results from communication through the train is bought. The cost of transporting dead weight has been greatly exaggerated, and it is quite certain under ordinary circumstances an increase of even as much as 50 per cent. of such weight adds very little to the expense of operating a road.

With reference to steadiness of motion it is largely a matter of the condition of the track. It must not be forgotten, though, that it is more important that a car should remain on the track than that it should ride steadily. Oscillation at high speeds and on an uneven or crooked road is, to a great extent, the result of an adaptation of the running gear to the inequalities of the road. In some cases if a car did not oscillate it would be liable to leave the track. It is, we think, unquestionably true that under all conditions of track that long cars with trucks or bogies run more smoothly and evenly than short cars without trucks, and on a rough road at considerable speeds there will be the difference that cars with trucks will remain on the track, whereas those without—if their wheel-bases are long enough to give steadiness—will not.

With reference to general comfort it must be admitted that no American cars have as yet been supplied with seats which are as comfortable as some of those in first-class English cars. For some reason American railroad managers have been slow to perceive that to make a seat comfortable abundant room is essential—room lengthwise, crosswise, and vertically. The Boston & Albany Railroad Company, for example, have spared no expense in building luxurious cars, and yet they crowd their passengers into seats which are spaced only 33½ in. from center to center. But every degree of roominess is now given in the seats of American cars. Reclining chairs of every variety can be had, adapted for any position of the passenger, except standing on his head, and he might even do that, if he is not comfortable without, so that if Japanese travelers yearn to "stretch their legs," American cars can be supplied which will give them unlimited opportunities for that exercise.

In the matter of classification of passengers, American practice offers a variety of systems to choose from. On many lines and trains there is but one common class, and one rate of fare. On other lines or trains there are parlor or drawing-room cars by day and sleeping-cars at night, and in some cases emigrant trains or cars for those who want to travel cheaply. "You pays your money and you takes your choice."

With reference to speed there, too, a wide choice is open. Some American trains run as fast as the fastest in England, although there are more fast ones there than here, but it is questionable whether very high speeds would be practicable or desirable on Japanese roads; but our American cars and locomotives are adapted for high speeds, as well as English rolling-stock is.

With reference to cost of construction there can be no doubt that the average cost per mile of American railroads is less than that of English roads, but that proves very little, excepting, perhaps, that those who built them here had less money to spend than the English brethren had. The truth is, the roads here have been built to meet the needs of the country. When there was a sparse population and little traffic the lines were pushed out with as little cost as possible. The road-way was cheap, and the rolling-stock and conveniences of travel were in accordance with and adapted to the needs of the section in which the lines were constructed. As population increased and the demands of the public became more exacting the roads and rolling-stock were improved, speed was increased, more luxurious stations were provided, heavier rails were laid, and more substantial bridges and other structures built.

Our foreign contemporary says of "social barriers" that, "if our friends and kinsmen beyond the water please to flatter their fancies by pretty dreams of universal brotherhood and sisterhood, let them have their foible." Whether "social barriers" are foibles or not, it is hardly worth while to discuss here. If the Japanese see proper to maintain them, American railroad practice will give abundant means to indulge the "foible." What is claimed for the American system of railroad building is that it is adapted to any condition of things likely to occur in a country like Japan. Under like conditions its cost is less than the system of construction which has been developed in England.

The *Mail* quotes some figures to show that the cost of operation of English roads is less than that of American lines. The basis of these data is the relative percentage which the working expenses bear to the receipts. It has been shown over and over again that such figures are delusive, as the rates received for the traffic are, in this country, constantly changing. If the rates are reduced the receipts are correspondingly diminished, but the expenses remain unchanged, so that the much-quoted percentage of expenses to receipts is really a function of the rates charged.

Regarding accidents, too, no comparison is possible, because no official or correct record is kept in this country, excepting in a few States, and the average length of the journeys traveled is not known correctly in either country. In any event, though, the frequency or infrequency of accidents is due more to good management in operating than to the adoption of either an American or European system of construction.

The question of whether the railroads of Japan shall be well or badly managed, does not depend upon the selection of either system. The perfection of their railroads, too, will depend largely upon the knowledge, ability, and integrity of those who have charge of them. Official corruption on railroads is a great evil in this country, but is not inherent in our system of construction. We believe the venerable practice of beheading criminal officials still exists in Japan. Let the Japanese

adopt, as part of their railroad system, an inexorable law that any railroad official who accepts a bribe in the performance of his duties shall be beheaded, and they will escape many evils which have attended the development of the railroad system here.

THE SIBERIAN PACIFIC RAILROAD.

THE longest single line of railroad now seriously contemplated in the world is the Siberian Pacific Railroad, upon which the Russian engineers have been for some time engaged, and on which it is understood the Russian Government intends to begin work early in the coming year. This line is of interest, not only on account of its length, but from the fact that it will follow a route upon which there has been for many years a considerable commerce carried by somewhat primitive methods, and that it will aid in opening up and improving what is probably the greatest extent of undeveloped territory in the world, outside of the continent of Africa. Southern Siberia is, outside of Russia, almost an unknown country, but its productive capacity is undoubtedly great, and when made accessible and opened up to settlement—perhaps relieved from the incubus which always weighs a penal colony—it will appear as a new competitor on the markets of the world, and will yield sufficient traffic to support, not only one, but possibly several railroads.

The Siberian road, while purely a Government enterprise, differs from the Transcaspian line, from the fact that it will be built for commercial reasons chiefly, and not as a purely military road. The object of the Government is not only to open the country, but to furnish a convenient line for the Chinese trade, and to establish a connection with the Russian settlements and naval stations on the Pacific, which will probably play an important part in the future contest for naval and commercial supremacy, in which Russia undoubtedly expects to take a prominent part.

While the general plan of this Siberian road has been outlined, the location, except for a short distance at the western end, has hardly been begun, and for a greater part of its length nothing more than a slight preliminary reconnoissance can be said to have been made; nevertheless the country has been carefully studied for several years past, and it is understood that a very fair idea has been reached of the work which must actually be done.

The outlined plan of the road is for a line nearly 4,000 miles in length, extending from Tiumen, in western Siberia, the present terminus of the Oural Railroad, to Vladivostock, the chief Russian port on the Pacific coast. This line is divided into five principal sections, the first extending from Tiumen to Tomsk, the most important city in southern Siberia, a distance of 800 miles; the second section is from Tomsk to Irkoutsk, 1,050 miles; the third, from Irkoutsk to Oust-Strjelka, 800 miles; the fourth will follow the valley of the Amoor for 1,000 miles from Oust-Strjelka to Usuri, while the fifth section is a short one of 300 miles, leaving the Amoor at Usuri, and running nearly due south to Vladivostock.

These sections mark the chief geographical divisions of the line, but it is not proposed to build them all at once. In order to complete the line of communication as soon as possible, the intention is, it is said, to begin work at Tomsk, and to build the section from that place to Irkoutsk, as there already exists a navigable line from Tiumen to Tomsk by the Irtish and the Obi rivers. The construction of this section will be followed by that from Irkoutsk to Oust-Strjelka, both of these being through a region where a land route alone is available. The section of 1,000 miles from Oust-Strjelka to Usuri is covered by steamboat navigation on the Amoor and its tributaries, but Vladivostock lies away from the mouth of that river, and can only be connected with it by rail, so that the 300 miles necessary for that purpose will probably be almost the first part of the line to be built.

The three sections named include a total of somewhat over 2,100 miles, leaving about 1,850 miles which will have to be built later to complete the railroad line. It is said that the final rail terminus will not be at Vladivostock, which is not satisfactory as a port, and that the real intention is to carry the line further south, probably—if political considerations do not prevent—to a Corean port, one of the few good harbors on the Japanese Sea. This, however, is a matter of future consideration.

The greater part of the country through which this road will pass presents few or no engineering difficulties. For nearly 1,000 miles the route is over an almost level plain, where the only works of importance will be the river crossings, which will require some bridges of considerable size; but should haste, as well as economy in construction, be an object, most of these could be crossed, for a time at any rate, by steam ferries. The most important of these crossings will be those of the Tobol at Tobolsk, the Irtish at Omsk, the Obi east of Tomsk, the Tom at that city and the Yenisei at Krasnojarsk, all of which will require long and expensive bridges. It must also be remembered that in these rivers, and also in many of the smaller tributaries, the bridge substructures will have to be of very firm and solid construction in order to resist the great pressure of the ice in winter and spring.

The principal engineering difficulties will be found on the central section, where the road rises from the valley of the Irtish and crosses the Baikal Range, to reach Lake Baikal, which lies at a level of some 1,500 ft. above the sea, and must again descend from the lake and cross the Jablonoi Mountains which divide it from the valley of the upper Amoor. It is said, however, that passes have been found through the Jablonoi Mountains, through which the road can be carried at a level only slightly above that of the lake, and that one or more of these passes can be reached without the use of excessive grades, while the crossing of the hills to the westward of Lake Baikal can, by a slight detour, be made without encountering serious difficulties. Through the Amoor Valley the work will be easy, while from that river to the Pacific terminus the line can be run through a rolling country, presenting no great elevations or depressions. The winters, however, in the neighborhood of Lake Baikal are long and very severe, and more difficulty may possibly be encountered in operating the road than in constructing it. On the remainder of the line, while the winter climate is somewhat rigorous, it is stated that the snows are lighter and that less trouble may be expected than on many of the lines in Europe and Russia.

The consideration of this project has proceeded so far that already estimates have been made of the cost. The lowest, based upon the experience of the Government with the Transcaspian line, is that it will be from $25,000 to $30,000 per mile, while for a more permanent line, with allowance made for the solid construction required to

withstand the severe winters, the estimate is as high as $40,000 per mile. The actual cost will probably be somewhere between the two extremes; in all the estimates allowance has been made for the cost of hauling material over the long distances which will be required.

The full usefulness of the line will not be reached without several branches, and provision will be made for the building of these almost at the same time with the main line. Three or four will diverge to the northward and reach the more important of the Siberian cities, while one at least will be carried to the Chinese frontier—possibly across it—in the direction of Kiachta, which has for many years been the center of Russian trade with China. It is not improbable also that a branch from some point near the western end of the road may cross the Kara Mountains and join the Transcaspian road near Khojend, thus giving the Siberian line an outlet to the Caspian Sea, in addition to its connection with the Russian railroad system.

NEW PUBLICATIONS.

PRACTICAL DESIGNING OF RETAINING WALLS: by PROFESSOR WILLIAM CAIN, A.M., C.E., SOUTH CAROLINA MILITARY ACADEMY. New York; D. Van Nostrand (price, 50 cents).

This excellent treatise of Professor Cain's, which was intended to be a revision of the original work of Arthur Jacob, but which was practically a new book, was issued some time ago as No. 3 of Van Nostrand's "Science Series." It has now been reissued, with the addition of an appendix giving a design for a very high masonry dam. This is of interest in view of the discussion which the Quaker Bridge Dam has caused, and, indeed, the design given and analyzed was prepared especially to meet the conditions presented by that dam.

THE STEAM BOILER CATECHISM: A PRACTICAL BOOK FOR STEAM ENGINEERS, FIREMEN, OWNERS, AND MAKERS OF BOILERS OF EVERY KIND: by ROBERT GRIMSHAW, M.E. New York; the Practical Publishing Company, No. 21 Park Row (price, $2).

This book is intended to be a practical treatise on the Steam Boiler, and a companion work to the *Steam Engine Catechism* and the *Pump Catechism* by the same Author. It is a compilation and collection of facts relating to boiler construction and management, presented with the intention of making them not only readily accessible, but clear and plain to any reader of ordinary education. The book is written in the form of question and answer—a form which, without doubt, presents many advantages in a work of this kind.

A minor objection to the book is its form. The small size of page was probably adopted with a view of making a book which could be carried in the pocket; but where the size runs up to over 400 pages, as in this case, it grows uncomfortably thick. Moreover, the small page limits the size of engravings, so that many must either be put in as folding leaves or insets—always a bad thing in a book—or else made on a smaller scale than they should be to be clear and agreeable to the eye.

These are minor objections, however, and the Boiler Catechism ought to fill a considerable field. There is room for it, for there has been till recently no practical book on boilers which is readily obtainable or within the means of many men to whom it would be useful. It is a book for learners rather than for experts, aiming to present to them the results of experience and approved practice.

One thing, which is too often lacking in books of this kind, a sufficient Index, is given in this work, and there is little fault to be found with its general plan and arrangement.

TWENTY YEARS WITH THE INDICATOR, BEING A PRACTICAL TEXT-BOOK FOR THE ENGINEER OR THE STUDENT, WITH NO COMPLEX FORMULÆ: NEWLY ARRANGED AND COMPLETED IN ONE VOLUME: BY THOMAS PRAY, JR., M.E. New York; John Wiley & Sons, 15 Astor Place, and London; E. & F. N. Spon.

This book is intended to present the results of many years' observation and experience with the indicator, in the form of a practical handbook, or text-book, for the working engineer, the steam user, or the student. It gives a description of the indicator and the method of applying it, illustrated by many cases drawn from practice, and goes on to show the use to which it may be put and the lessons to be drawn from its showing.

The applications made include many forms of stationary engines, and also marine engines of a variety of types. The object has been, as the Author says, not to criticise or to favor any special kind of engine, but to give the conclusions drawn from a wide experience, to record facts, and to show how further facts can be ascertained, and the lessons drawn from them and applied to the best advantage.

The use of the indicator has been very much extended in the past few years, and with excellent results. Occasionally, in incompetent hands, some harm may have been done by conclusions hastily or incorrectly drawn, but in the main the employment of this instrument has added to our knowledge, and has been the cause of many improvements in engine practice. Mr. Pray's book is a very convenient and useful manual, and will repay study by those for whom it is intended.

POOR'S DIRECTORY OF RAILROAD OFFICIALS: THIRD ANNUAL NUMBER, 1888. New York; Poor's Railroad Manual, 70 Wall Street.

This is the annual supplement to *Poor's Manual*, containing the names and addresses of railroad officers, which for three years past have been given in a volume separate from the *Manual*. It contains, in the first place, an alphabetical list of railroad companies, giving the directors and officers of each company. This is supplemented by an alphabetical index of names, containing the names of all the officers given in the book, with references to the pages on which they may be found under their proper headings. In addition to the steam railroads there is also given a list of logging, and other private railroads, with names of their owners. This is a very convenient addition for many purposes, although it must be necessarily a difficult one to make complete. How complete it is in this volume, we have no means of judging. There is also a list of the street railroads of the United States, giving their location and officers and separate lists, which are intended to save time to those using the book, giving in one the General Managers or General Superintendents of the principal railroads, in another the Chief Engineers, in a third the General Freight and Passenger Agents, in a fourth the Master Mechanics, in a fifth the Master Car-Builders, in a sixth the

Master Car-Painters, and lastly, in a seventh the Purchasing Agents. There are also lists of Bridge-Builders, of Car-Builders, Car-Wheel, Spring, and Axle Manufacturers, Locomotive-Builders and of Rail Mills, and Railroad Contractors. A list of railroad associations is also given, and the names of the Railroad Commissioners of the several States complete the information presented, with the exception of some pages occupied by a directory of the Mexican, Central American, and South American railroads, and a few pages on the railroads of Great Britain and Ireland.

The information given seems to have been carefully collected and prepared, although a slight examination has shown some mistakes in the list of manufacturers, especially the car and locomotive builders. The book, however, is a very useful one, and almost indispensable to any one engaged in railroad or kindred business. There is one advantage in having the *Directory* in a separate volume from the *Manual*, and that is that the *Manual* itself is now necessarily so large a book as to be somewhat cumbrous for constant use, while the *Directory* is a much smaller and more convenient volume.

CHINA. TRAVELS AND INVESTIGATIONS IN THE MIDDLE KINGDOM: A STUDY OF ITS CIVILIZATION AND ITS POSSIBILITIES, WITH A GLANCE AT JAPAN. BY JAMES HARRISON WILSON, LATE MAJOR-GENERAL, U. S. VOLS., AND BREVET MAJOR-GENERAL, U.S.A. New York; D. Appleton & Company.

General Wilson made an extended visit in China, going there in the fall of 1885, and remaining there for nearly a year, his object being to see to what extent the country was available at the present time as a field for investment of foreign capital. Whether the people were ready for railroads; whether, if built, they would pay; and, further, whether the construction and management could be secured for Americans upon such terms as would return a fair interest on the capital invested, with due regard to the risks involved. Carrying with him introductions to men high in official position he was enabled to see much more of the real industrial and economic condition of the country than most travelers are enabled to do, and he spent his time in making a careful study of the country and people. The results of his observations are given in the present volume, which contains an account of his travels and of his interviews with Chinese officials, with some carefully-made studies from such statistics as he was enabled to procure from the closely-guarded Chinese official records. He has also some interesting remarks on the nature of the Chinese Government, and the results of some past movements in that country, including the Tai-Ping Rebellion, the origin and course of which have always been somewhat of a mystery to foreigners.

His conclusions were in some respects favorable, in others not; he is inclined to believe that the people and country are ripe for railroads, and that there is an excellent opportunity for introducing Western industrial methods in the opening of mines, the working of metals, etc., but he is not inclined to believe that this work will be done, to any great extent, by foreign capital, or by foreign labor. "It will be done," he says, "whenever they can be shown that these can be done with their own money and by their own labor, under the direction of foreign experts, who will treat them fairly and honestly." The only probable market which he foresees for foreigners is in the supply of material and equipment for the first railroad lines to be built.

General Wilson has given us in this volume, not only an entertaining record of travel but also a better and more compact view of the present political and industrial situation of China than any probably which has yet been published, for, although he does not profess to have made or attempted an elaborate work, he has nevertheless given in a brief and readable form much that is valuable and interesting to students of the present condition and probable future prospects of the "Middle Kingdom."

ABOUT BOOKS AND PERIODICALS.

THE POPULAR SCIENCE MONTHLY for November has an article on the Problem of a Flying Machine, by Professor Joseph W. Le Conte, in which the question of aerial transportation is discussed. Altruism Economically Considered, by Charles W. Smiley, is an article which will repay reading by all who are interested in social questions.

Mr. McKennan's remarkable series of articles on Siberia in the CENTURY MAGAZINE, while devoted chiefly to the consideration of the exile question, have much that is of interest on the resources and nature of that vast country, which has heretofore been almost unknown.

A novel "Time Table with Notes" is issued by the Chicago, Burlington & Quincy Railroad. It contains a description of "The Burlington's Number One Train," as surpassing all others in speed, leaving Chicago daily at noon and reaching Denver at nine o'clock the next evening; an account of the important stations along the route; also a map showing the through lines of the Burlington route.

This Time Table will be a great saving to conductors, as it answers many of the questions which they have been compelled to answer heretofore, and gives travelers the information which they would naturally ask for.

A neat and very attractive advertisement, in the form of a miniature copy of SCRIBNER'S MAGAZINE, is issued. It contains several reduced illustrations, Twenty Questions About Railroads, Railroad Signals, as in use on a majority of American Railroads, and Rules for Train Management; it also gives a few of the features offered to the readers of the Magazine during 1889, including articles on Railroad Management, by General E. P. Alexander; the Railroad Postal Service, by ex-Postmaster-General Thomas L. James; Railroad Accidents, etc.

BOOKS RECEIVED.

FACTS ABOUT IRELAND: A CURVE-HISTORY OF RECENT YEARS: BY ALEXANDER B. MCDOWELL, M.A. London; published by Edward Stanford.

OCCASIONAL PAPERS OF THE INSTITUTION OF CIVIL ENGINEERS. London, England; issued by the Institution. The present installment of these papers includes the River Clyde, by Daniel Macalister; a New Method of Investigation Applied to the Action of Steam-Engine Governors, by Professor V. Dwelshauvers-Dery; Alpine Engineering, by Leveson Francis Vernon-Harcourt.

SIXTEENTH ANNUAL REPORT OF THE COMMISSIONER OF RAILROADS OF THE STATE OF MICHIGAN FOR THE YEAR 1888: JOHN T. RICH, COMMISSIONER. Lansing, Mich.; State Printers.

THE GOULDS MANUFACTURING COMPANY CATALOGUE OF PUMPS AND HYDRAULIC MACHINERY: TWENTY-SEVENTH EDITION, 1888-89. Issued by the Goulds Manufacturing Company, Seneca Falls, N. Y., and 60 Barclay Street, New York. This is an exceedingly neat and complete catalogue of the kind, including pumps and pumping machinery of almost every description.

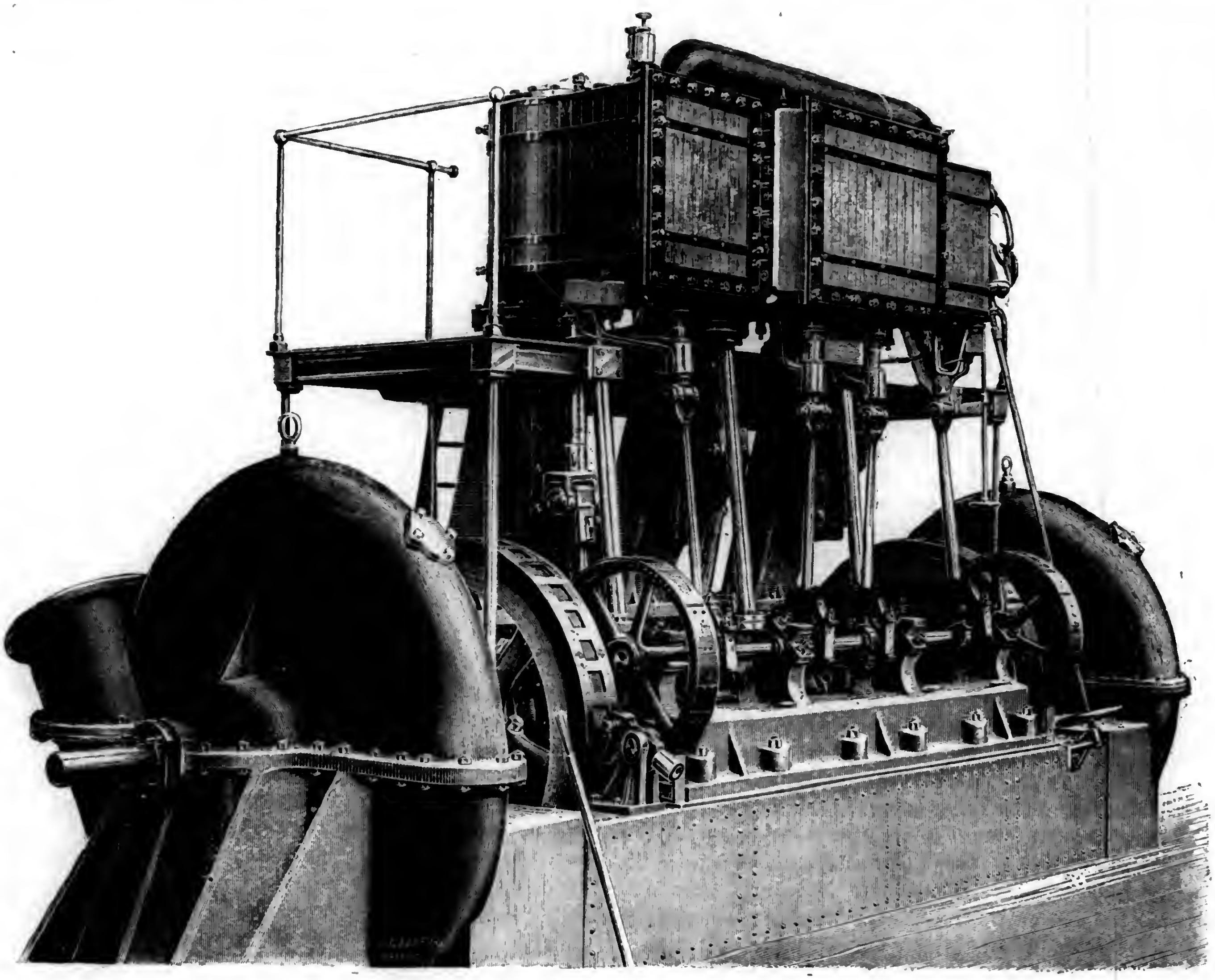
WELDING, TEMPERING, BRAZING, FORGING, AND SHAPING OF METALS BY ELECTRICITY. Boston, Mass.; issued by the Thomson Electric Welding Company.

HARRINGTON'S SCREW-HOISTING MACHINES, HAND-POWER ELEVATORS, AND OVERHEAD TRAMWAY SYSTEM: CATALOGUE. Philadelphia; Edwin Harrington, Son & Company.

TRIPLE-EXPANSION PUMPING ENGINES FOR AUSTRALIA.

(From the London *Engineer*.)

THE accompanying engravings show a fine set of pumping machinery of the triple-expansion type—the first, we believe, which has been applied to centrifugal pumping—constructed by the firm of W. H. Allen & Company, of York Street Works, Lambeth. These pumps will be shortly erected at Mildura, Australia, where a complete irrigation scheme will commence. The pumps themselves are of the centrifugal form, and are capable of discharging 23,000,000 gallons per day to a height of 35 ft. at 200 revolutions per minute. The engines are generally of the marine type, and are fitted with cylinders 13 in., 22½ in., and 34 in. diameter by 18 in. stroke, running at 200 revolutions per minute, giving a piston speed of 600 ft. per minute. The pressure of steam is 140 lbs. at the cylinders. The engines are connected direct to the centrifugal pumps,



TRIPLE-EXPANSION ENGINES WITH CENTRIFUGAL PUMPS.

BUILT BY W. H. ALLEN & COMPANY, LAMBETH, ENGLAND.

and, as will be seen, are mounted upon a strong wrought-iron bed-plate, to which are attached the two pumps. The engines have been made with all the latest improvements, and are supplied with a separate combined direct-acting air-pump of unusually large dimensions, on account of the high temperature of the condensing water, which averages as much as 80 degrees; the air-pump is mounted upon a massive cast-iron bed-plate having the engine attached thereto. This engine will have to travel about the same speed as the main engines to maintain the desired vacuum. The engines are finished bright, and very similar to the usual high-class work in waterworks engines. For low-lift pumping of any kind, whether for drainage or irrigation, this particular combination offers great possible advantage, by reason of its economical working.

THE PRINCIPLES OF RAILROAD LOCATION.

BY PROFESSOR C. D. JAMESON.

(*Continued from page* 491.)

CHAPTER XXXVIII.

LAYING OUT CUTS AND FILLS.

THE method that is used is more easily executed than explained. In the level cuts or fills, the side heights or elevation of the slope stakes are the same as the center stake, and the side distances are obtained as we have explained. In the example now before us this is not the case, however.

On one side the slope stake is higher than the center stake, and on the other lower. Still, taking the fill at the slope stakes

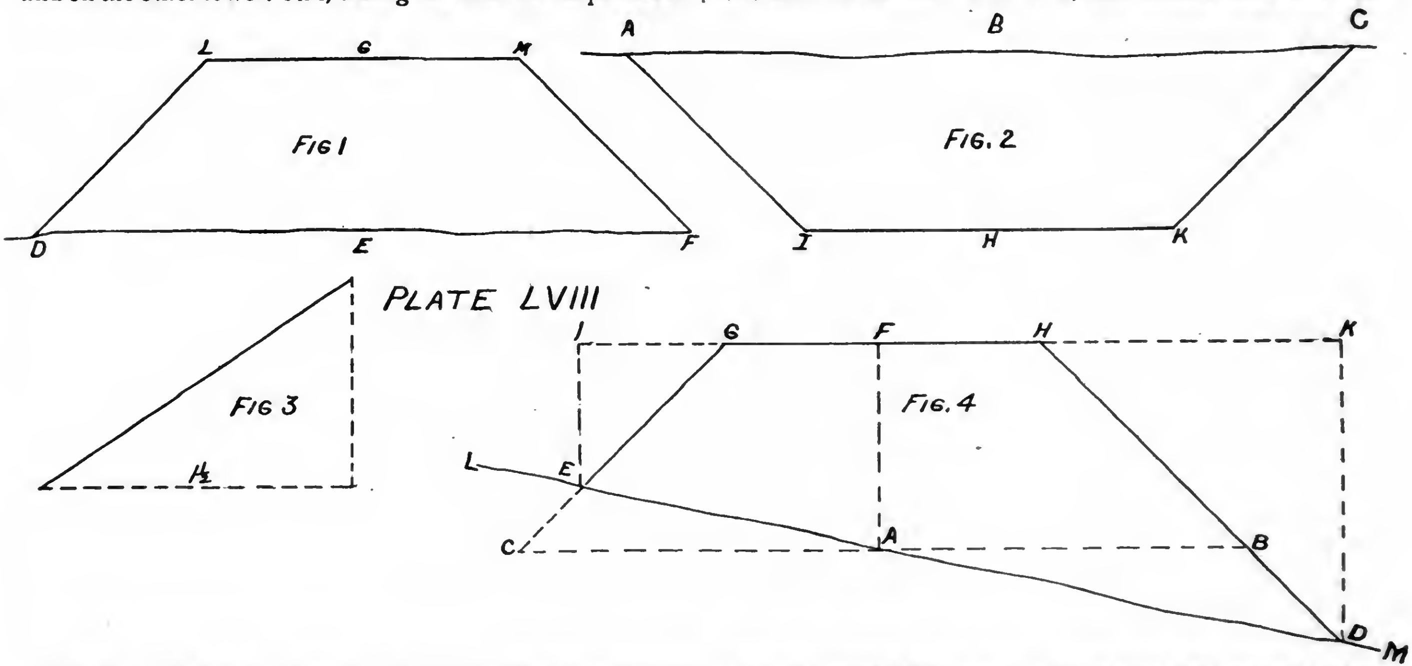


PLATE LVIII

—that is, *I E* or *K D*, Plate LVIII—multiply either by the ratio of slope, and add to the product one-half the width of the road-bed, and the result will be equal to *I G* or *H K*. The work is best done with a Wye level, and the points *E* and *D* found by trial. Assume some point on the ground at as nearly a right angle with the center line at the center stake used as can be judged by the eye. Measure its hor-

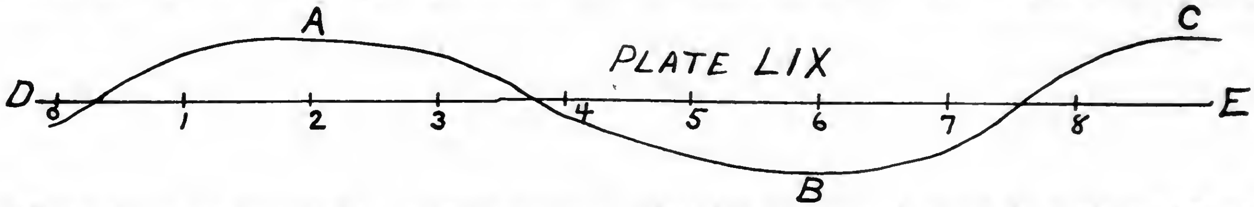


PLATE LIX

izontal distance from the center stake. Have the level-rod held on it, and find the difference between its elevation and the elevation of the grade at the center stake used. Multiply this difference in elevation (or, in other words, the side cut or fill) by the ratio of side slope. Add one-half the width of the road-bed to the product, and if the result equals the distance of the assumed point from the center stake, the assumed point is the correct position for the slope stake. In case the side distance and the above result do not coincide, then move the rod to another trial point. The rapidity with which these stakes can be put in depends solely upon the skill and ability of the leveler.

But with practice one or two trials only are necessary in the majority of cases.

At the same time the slope stakes are being put in there should also be put in stakes at those points where the grade line cuts the surface of the ground—that is, where the character of the work changes from a cut to a fill, or *vice versa*.

Thus, in Plate LIX, let *A B C* represent the surface of the ground on the center line, and *D E* the grade line, 1, 2, 3, 4, 5, 6, etc., representing the stations. At the point *L* the work passes from a cut *A* to a fill *B*, and at *M* from a fill *B* to a cut *C*. These points, *M* and *L*, should be found on the ground by means of trial with the level and stakes marked "grade" put in at them. When there is only one grade stake put in at each point it should be on the center line. Where the ground is very irregular it is sometimes advisable to put in not only the center grade stake, but also one on each side of it, and distant from the center line by one-half the width of the road-bed, as such points as where the each edge of the road-bed cut the surface.

The distances to all these stakes should be carefully taken in reference to some center stake and recorded, so that they can at any time be replaced if lost.

In side-hill work—that is, where the work on one side of the center line is in cut and the other in fill, as shown in Plate LX, the point *A*, where the grade cuts the natural slope, should be marked by a stake, and its distance from the center stake measured and recorded in the cross-section book.

When the slope stakes are put in we have the following record of the work, as shown in Plate LXI:

1. The number of the stations and the plus stations, where for any reason a stake has been put in, such as a grade stake.

Down the center of the page, column 3, the center heights, or the cuts and fills on the center line, with the appropriate sign; on each side of this, columns 2 and 4, we

have the side distances written above the line, as the numerator, and the side heights written below the line, as the denominator, with its appropriate sign.

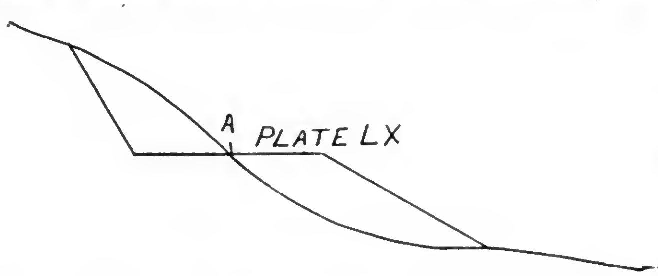
From these notes any of the stakes can be replaced at any time if lost.

From these cross-section notes that are taken in the field can be calculated at once the cubical amount of material that must be moved in the construction of the railroad.

CHAPTER XXXIX.

ESTIMATING COST OF CONSTRUCTION.

In estimating the probable cost of construction, it is necessary to know the total amount of material (usually in cubic yards or meters) that must be moved, and also approximately the classification of this material—that is, what amount will be solid rock, what hard-pan, and what earth. There are innumerable other factors, the probable cost of which must be included in any preliminary esti-



mate. The most important of these factors will be considered in their regular order.

1. The cubic contents and position of every cut and fill, with a classification of the material.

2. The cubic contents and class of work that is to be put into every masonry structure, the position of the structure, and its estimated cost finished.

3. Length and position of every opening in the road-bed, with the manner and material by which it is going to be spanned. The weight and probable cost of all iron and steel that is to be used. Number of feet of lumber needed and probable cost.

These are the most important factors that have to be considered in a PRELIMINARY ESTIMATE, and when we are to estimate the cost in actual dollars and cents, the question of the supply and cost of labor becomes a very important item.

In making a preliminary estimate, it must always be remembered that the results to be obtained are not required to run to three or four decimal places. Seldom more than one, and often simply the even quantities will give a result not only sufficiently accurate for all practical purposes, but *actually* as accurate as if the calculations had been worked out with great mathematical exactness. What is desired in every case is reasonable accuracy, no cumulative error, and the whole work done in the least possible time.

In all preliminary work saving of time is the great object, whether it is preliminary work in the field or preliminary estimates in the office. We will take up first the calculation of earthwork. This includes rock, hard-pan, and earth. It is absolutely impossible to calculate the number of cubic yards of material in any one station with greater accuracy than one decimal place, unless an amount of field work was done that would be all out of proportion with the results obtained. This is due to the natural irregularities of the ground between the stations. In any practical method, the sides of the prism between any two stations are supposed to be plane surfaces, which they are not, as can be easily seen ; and suppose even that with an extreme refinement of calculation they are treated by means of calculus as warped surfaces, even then many of the irregularities of the ground would not be taken into account, and the final result would be actually no nearer the exact amount of material than if some of the more simple methods were used.

In Plate LXII, fig. 1, let $F\,G\,H\,D$ represent the section of a cut at right angles to the center line of the road. This is a similar section to what we would have at every station of the road in cut, and the reverse with a narrower road-bed is what we would have in fill.

We will suppose that the station next to the one shown in Plate LXII, fig. 1, is still in cut, and therefore in general outline is similar to it, although the center height, $A\,B$, will in all probability be different, the surface slope different, and the side distances, $F\,A$ and $A\,D$, different. We will assume the stations to be 100 ft. apart, and we then have the problem to find the contents of a prism 100 ft. long, with parallel ends similar to fig. 1, Plate LXII, as shown in Plate LXII, fig. 2. By any method that can be used, the areas of the end sections, Plate LXII, fig. 2, A and B, must be calculated. From the cross-section notes taken in the field for the location of the slope stakes, we have the

PLATE LXI

Sta.	L.	C.H.	R.
0	$+\frac{34}{14}$	+20	$+\frac{49}{26}$
1	$+\frac{22}{8}$	+10	$+\frac{31}{14}$
2	$+\frac{10}{0}$	+4	$+\frac{22}{8}$
+30	00	0	0 0
3	$-\frac{29}{14}$	−6	$-\frac{8}{0}$
4	$-\frac{56}{32}$	−20	$-\frac{23}{10}$
5	$-\frac{44}{30}$	−30	$-\frac{32}{16}$

center height, $A\,B$, Plate LXII, fig. 1, the side distances, $A\,F$ and $A\,D$, and the side heights, $F\,E$ and $D\,C$. We also know the width of the road-bed, W, and the ratio of slope, N, which are constant for any one cut or fill. The area of this polygon, $F\,D\,H\,G$, may be found by either of the following formulas :

$$A = \frac{C\,D}{2} + \frac{S\,W}{4}. \qquad (1)$$

A = area ;
C = center height, $A\,B$;
D = sum of side distances, $A\,F + A\,D$;
S = sum of the side heights, $F\,E + D\,C$;

W = width of road-bed, $G\,H$, or

$$A = \left(\frac{C}{2} + \frac{W}{4\,N}\right) D - \frac{W^2}{4\,N}. \qquad (2)$$

N = ratio of slope, and the other letters represent the same as in the first formula. The formulas 1 and 2 will give the area of any "three-level" sections. By a "three-level" section is meant one where the center height and the two side heights are given. In contradistinction to those where only the width of road-bed, angle of slope, and center height are given, or those where, owing to irregularities in the surface or the large size of the work, five or more elevations are taken in the cross-sectioning. After having obtained the end areas and as many intermediate areas as may be deemed necessary, the next thing is to find the solid contents of the prisms of which these are sections. The length of these prisms in ordinary American railroad practice is 100 ft., and among the innumerable methods used in finding the cubic contents, the two following ones are all that will be explained here, owing to the facility with which they can be used, and also owing to the fact that the results obtained are as accurate as any of the more complicated methods on account of the inaccuracy, unavoidable in the data we have to start with. The method most in use is what is known as "average end areas."

$$M = \frac{A + B}{2}\,l;$$

M = cubic contents;
A and B the areas of the end sections;
l = length of the prism.

As we have said, the length of the prism is usually 100 ft. Now, if instead of dividing the sum of the end areas by two for the average end area, and multiplying the result by 100, the length of the prism, we multiply each end area respectively by one-half the length of the prism and add the results, the total will be the same.

We must divide this result by 27, the number of cubic feet in a cubic yard.

Therefore, multiplying equations 1 and 2 by $\frac{50}{27}$, we have

$$M = \frac{50}{54}\,C\,D + \frac{25}{54}\,S\,W \qquad (3)$$

$$M = \frac{50}{54}\left(C + \frac{W}{2\,N}\right) D - \frac{25\,W^2}{54\,N}, \qquad (4)$$

either of which equations will give the number of cubic yards in a required prism 50 ft. long. How nearly correct this result is depends upon the difference between the two end areas. If these end areas are equal, the result obtained by equations 3 or 4 will be correct, but otherwise it will always be in excess. The correction to be applied for this excess we will take up later.

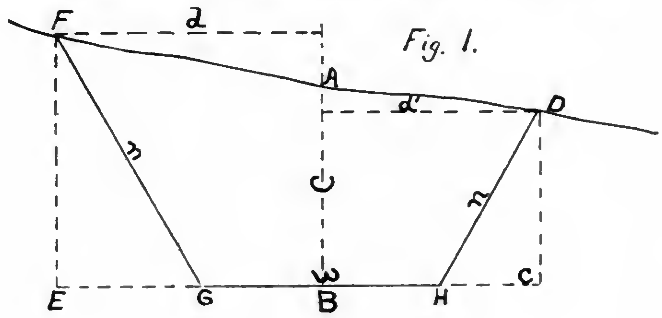


Fig. 1.

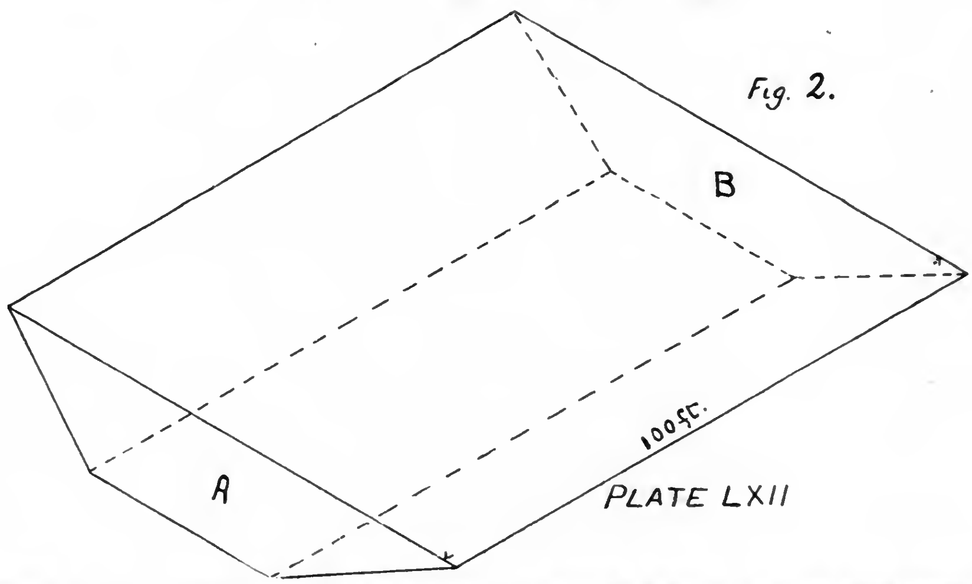


Fig. 2.

PLATE LXII

Another method that is always given in all text-books on the subject as the most accurate, and one that is very seldom used in the field is the Prismoidal Formula.

$$M = \left(A + 4\,C + B\right)\frac{l}{6}. \qquad (5)$$

M = cubic contents;
A = one end area;
C = area midway between A and B;
B = the other end area;
l = length of prism.

This formula undoubtedly gives the contents of the prism under all circumstances with much more accuracy than either 3 or 4. But it has this disadvantage: the dimensions of the area C must either be taken in the field, which doubles the amount of field work, or else approximated in the office by taking one-half the sum of the corresponding dimensions of the end sections for the dimensions of the middle section C. This greatly increases the office work.

But as the difference in the results given by the method of Average End Areas and the Prismoidal Formula depends upon the *difference* between the end areas and not upon the actual cubic contents of the prism, the following formula will give the correction, which should be subtracted from the result obtained from the end area formula.

$$P = \frac{C - C'}{3.24}\left(D - D'\right). \qquad (6)$$

$P =$ prismoidal correction.

C and $C' =$ respective center heights of the end sections.

D and $D' =$ respective sum of the side distances of the end areas.

This formula (6) gives the correction in cubic yards for the entire station 100 ft. long, and is to be subtracted from the total cubic contents of the station.

This formula (6) holds true without any regard being had to the width of the road-bed or the angle of slope.

When $C - C'$ or $D - D'$ only amounts to a few tenths of a foot, the correction is so small that it need not be taken into account.

There is one other correction which must be taken into account, and that is the correction on curves. It can be very readily seen that a right prism containing a certain number of cubic yards will have its volume changed if bent around the arc of a circle. The half of the prism on the outside will be increased, while that on the inside will be decreased. On light work and curves of long radii this difference would amount to very little, but where the work is heavy and the curve anyways sharp, this correction for curvature becomes a very important factor. The most simple form of employing this correction for curves is to find the amount that is to be added to or subtracted from the sum of the side distances, D, so that with the given radius of curve a new value of D may be obtained that, used in equations 3 or 4, will give the true volume of the prism.

$$D c = D + \frac{d - d'}{3 R} D \qquad (7) \text{ or}$$

$$D c = D + \frac{d^2 - d'^2}{3 R}. \qquad (8)$$

$D c =$ corrected value for D.

$d =$ side distance from the center stake toward the outside of curve.

$d' =$ side distance from center stake toward the inside of the curve.

$R =$ radius of the curve, or using d and d' without any regard to the direction of the curve, the correction is to be added when the side distance is the greater on the convex side of the curve, and subtracted when greater on the concave side.

When running to or from a tangent point only one-half the correction should be applied.

The diagram, Plate LXV, is calculated for curves of 10°, and substituting this radius for $3 R$ in equation 7, we have

$$D c = D \pm \frac{d - d'}{1719} D.$$

The last part of the equation being the correction that is taken from the diagram, and which must be added to or subtracted from D as the highest ground, is on the outside or inside of the curve.

This correction in the value of D should be made before any estimate of quantities has been made and the corrected value used in equations 3 or 4. We now have all the equations necessary for the calculation of the amount of material that must be moved in the construction of the sub-grade of a railroad. Should the occasion arise when it is necessary to calculate the volume of any irregular-shaped masses of material, the whole mass should be divided into triangular prisms, the end areas found, and the average end areas multiplied by the length of the prism.

CHAPTER XL.

DIAGRAMS AND TABLES IN ESTIMATING WORK.

If in calculating the volume of material in each station on the line equations 3 or 4 had to be solved, with the ever-changing values of its various terms, the process would be one occupying much time, and, considering the excessive amount of time necessary, of very little practical value. In the case of "level cuttings or fills" it is an extremely simple matter to calculate once for all a series of tables that shall include within their limits all probable dimensions, and there are many of these tables in existence. See Trautwine's "Engineers' Pocket Book," pp. 732–41. But in three-level sections, such as we have been considering, there are so many variable terms in the equations 3 and 4 that any set of tables of such an extent as to cover the ordinary dimensions of ordinary practice would be of such tremendous size as to be utterly of no use or value. But this objection is overcome. A series, not of tables, but of diagrams, can be constructed, from which with any of the probable dimensions the values of equations 3 and 4 can be read with greater speed and facility than from any series of tables, and with all necessary accuracy. The most complete treatise upon "Computation from Diagrams of Railway Earthwork" is by A. M. Wellington, C.E. Mr. Wellington gives a complete set of plates, covering all probable cases and dimensions that occur in railroad practice, and a book of explanation setting forth the principles upon which the diagrams have been constructed, with directions as to their use and great adaptability to all probable and possible cases.

The only drawback to the rapid and continuous use of these diagrams as published is, that all the lines upon them are printed in black, and owing to the great number of these lines, it is confusing and trying to the eyes.

On railroad work of any extent this can be entirely obviated by having a set of diagrams made in the drafting office upon cross-section paper, that engraved in green, with one inch divided into tenths, being the most suitable. The main lines can then be put in black and the subdivisions in red.

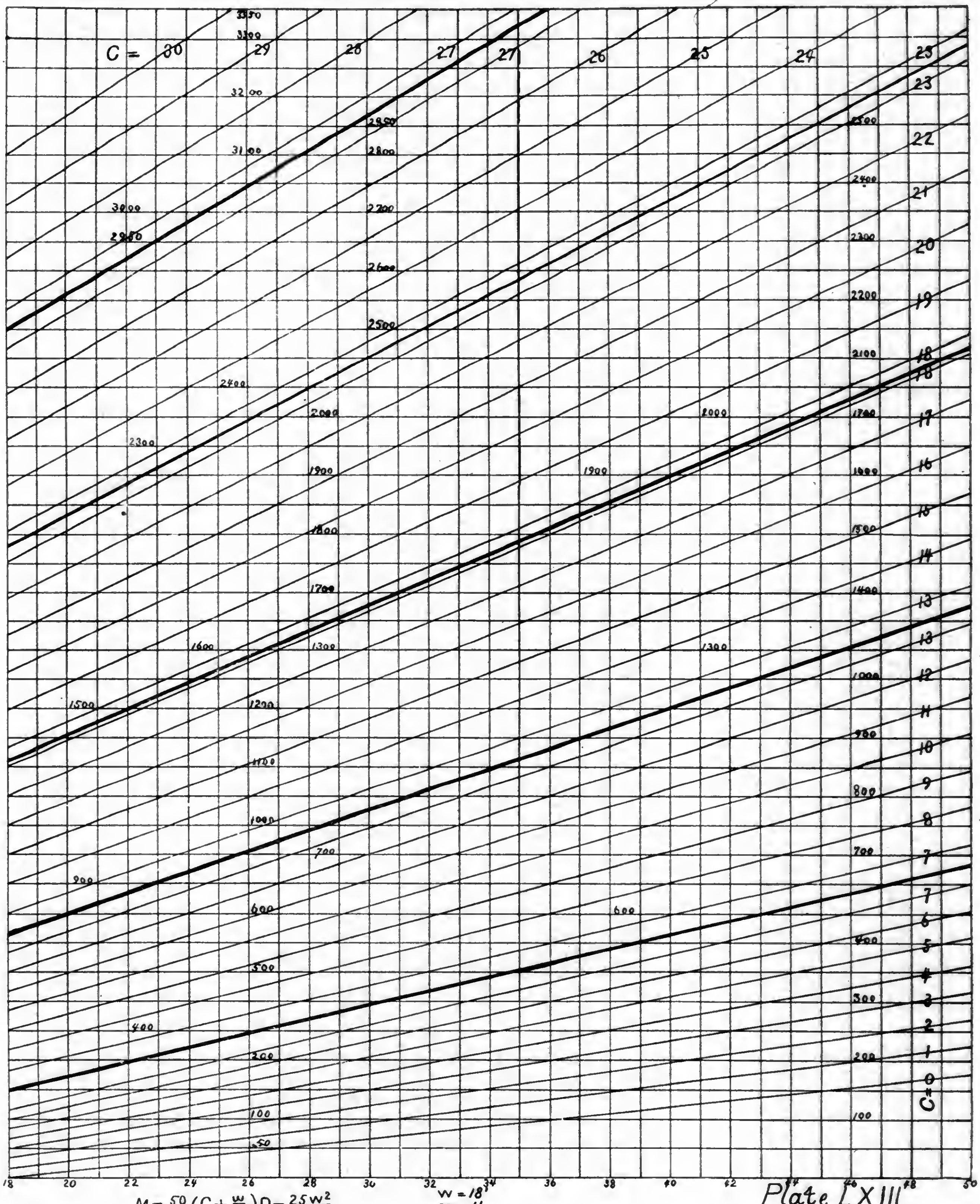
As upon any one railroad the width of road-bed and angle of slope would be uniform for all fills, only one diagram would be needed for this, and for cuts, one for each different slope that would be used. Three would probably be sufficient. Then with one containing the prismoidal correction and correction for curvature, the set would be complete—five in all.

Plate LXIII shows a reduced copy of a diagram for a road-bed of 18 ft. and the slopes one and one-half to one. On this copy the center heights are only taken at every even foot, as, owing to its reduced size, it is given simply as an example, and not for use.

The manner of construction is as follows: Take equation 4. The width of the road-bed (W) and ratio of slopes (N) are constants. We have for variables the distance be-

tween the slope stakes D, the center height C, and the volume M. The values of M are laid off upon the vertical lines and represented by the horizontal lines. The values of D are laid off upon the horizontal lines and represented by the vertical lines.

The different values for C are represented by the inclined lines. The manner of obtaining the lines representing values of C is by solving equation 4 for each required value of C, with the values of D taken at the probable minimum and maximum. In this way we obtain two values of M for two corresponding values of D. Follow up the vertical line representing the minimum value of D until it intersects with the horizontal line representing the value M as obtained by equation 4. At the intersection of these two lines make a point. Follow up the vertical line representing the maximum value of D until it intersects with the corresponding value of M, and make a point. A straight line connecting these points will represent the one value of C, and following up any vertical line representing some value of D until it intersects with this line C, the volume or value of M for these values of C and D will be represented by the horizontal line that intersects C at the same point that it is intersected by the given value of D.



$M = \frac{50}{54}(C + \frac{w}{2n})D - \frac{25w^2}{54n}$ $w = 18$ $n = 14$

Plate LXIII

Referring to Plate LXII, fig. 2, solving equation (4) with

$C = o$, $D = 18$, we have $M = o$; then with $C = o$, $D = 50$ we have $M = 177+$

Connecting point A on the left, $M = o$, with B on the right, $M = 177+$, we get the line $A\ B$, representing $C = o$, and by following up any of the vertical lines until they intersect with the line $A\ B$, we can then read off at once the value of M from the horizontal line that intersects at the same point.

In the same manner we can calculate the position and draw in lines representing all the required values of C. Thus, with $C = 6$ and $D = 18$ we have $M = 100$, and with $C = 6$ and $D = 50$ we have $M = 455+$

Supposing we had a cross-section that read $C = 6$, $D = 36$, and we have only to find the vertical line of $D = 36$ and follow it up until it intersects with the line $C = 6$. Then the horizontal line that intersects at this point will represent the value of M, and we have $M = 300$.

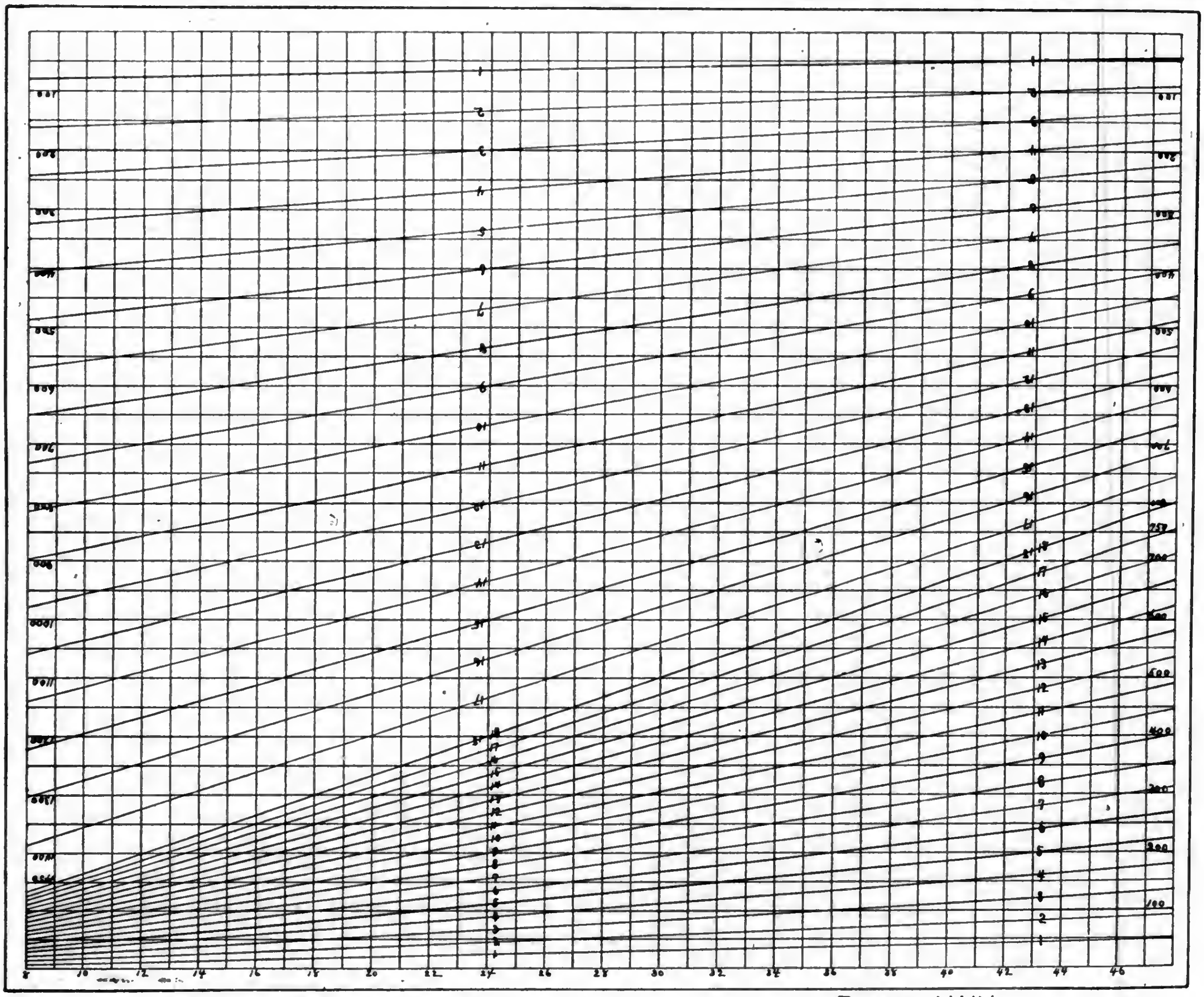
In order to insure perfect accuracy in the construction of the diagrams, many more points should be obtained for locating the lines of C than the two extreme ones. If the rectangular ruling of the paper was perfectly accurate in every way two points would be sufficient, but as this is not the case, it is a good plan to calculate about every fifth point and then connect them. Upon these diagrams can be put the curved line giving the values of M for level sections.

Plate LXIV is a reduced copy of a diagram of triangular prisms, and Plate LXV a diagram containing the prismoidal correction and the correction for curvature.

These diagrams are given merely as an illustration of what the diagrams are, and are not supposed to be either of sufficient size or detail for actual use.

The manner of using the diagrams is as follows:

Plate LXI is a sample page of the cross-section notes as taken in the field. The column marked $C\,H$ is the center cut or fill C. In the two columns marked L and R the numbers above the line are d and d'. The distance each way from the center to the slope stakes and their sum equals D. The numbers below the line are the side cuts or fills, or the distance above or below the grade line of the surface of the ground at the slope stakes. When it is desired to make the estimate with a degree of exactness that necessitates the use of the prismoidal correction, the amount of this correction which can be taken at once from a diagram similar to Plate LXV should be taken for each station, and these various amounts recorded opposite the respective stations in a column. Then by the use of a diagram similar to Plate LXIII, constructed from equation 4, with the required width of road-bed and angle of slope, the contents of the different prisms can at once be read off. Before this is done, however, the values of D should be determined (by taking the sum of d and d'). Then for any one station find the vertical line representing the value of D of that station, and follow it up until it cuts



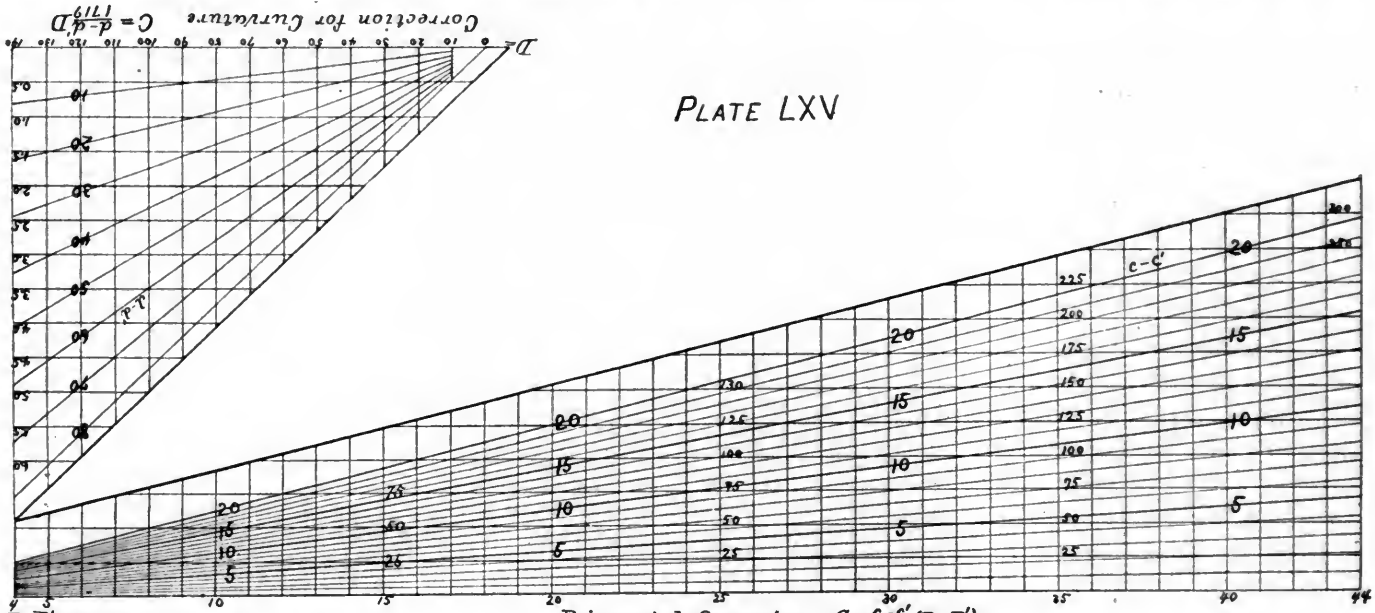
Triangular Prisms $M = \frac{50c}{54} D$

PLATE LXIV

the inclined line representing the value of C of that station, and read off the required value of M from the horizontal line intersecting at the same point.

The value of M as given by equation 4 is only for prisms 50 ft. long, and the sum of any two adjacent prisms will give the cubic contents of the entire station. From this total must be subtracted, if any, the amount of the prismoidal correction, in order to obtain the true value of M.

When a cut or fill occurs upon a curve of sufficiently short a radius to necessitate the correction for curves, this correction, which is a correction in the length of d and d',



should be taken from a diagram similar to that in Plate LXV, and the corrected values of d and d' written below the actual values, and the sum of the corrected values are what should be used with Plate LXIII.

(TO BE CONTINUED.)

NOTES ON RIVER CROSSINGS AND BRIDGE PIERS.

By M. Otagawa, M.E., Tokyo, Japan.

(*Continued from page* 495.)

IV.—EFFECT OF OBSTRUCTIONS TO RIVER DISCHARGE.

In narrowing the regimen of a river by bridge piers, a certain amount of obstruction to the river discharge is made. The equilibrium of the regimen in any part of a river is established between the abrasive energy of a river current and the cohesive strength of the materials which compose the bed of the river in the section in question. If now any obstruction, such as a bridge, be formed in the regimen, then the force with which the water acts on the bed is increased and a new equilibrium is established. What was lost in width by the bridge piers is to be regained by depth. This being the case, after a bridge has been built, the river will compensate for its lost area by scouring away its depth. Again, on the other hand, if by any cause the velocity of a river be diminished, there will be formed deposits on the bed. Therefore in bridging over a river we must know the velocity of the river at the site and the probable augmentation by the contraction of the channel. The latter must not be so great as to corrode the river-bed and destroy the foundations of the piers and abutments.

First, let us suppose that the material is very compact and tenacious, as in the case of rock. In this case, however great the velocity may be, water cannot attack the bed, and as far as the bridge is concerned it is quite safe. But as the water cannot acquire a great velocity, an eddy is formed above the bridge and the water will overflow. Next, suppose that the material under consideration is such that it easily yields to the action of water, as in the case of mud or sand; then precautions must be taken to prevent scouring taking place in one part of the bottom under the bridge and silting up on other parts, when the velocity is increased by the construction of a new bridge.

In determining the actual bottom velocities of rivers of considerable depth, it is not possible to place stationary current meters sufficiently deep. In some cases the bottom velocity varies considerably with the depth, even when the mean velocity remains constant. In a deep portion of a river water flows with more uniform velocity, but in a shallow part there is a marked difference between the greatest and least velocity. Dr. Rankine's formula giving the relation between bottom and mean velocity is this: The bottom velocity is as much less than the mean velocity as the surface velocity is greater than the mean.

Let m = mean velocity in feet per second;
v = surface " " " "
b = bottom " " " "
Then $b = 2m - v$.

It has been found by experience that the above rule gives an excessive value for the bottom velocity.

The force of impact of water upon materials obstructing the stream is directly proportional to the square of the velocity, and the resistance of the same material is proportional to their submerged weights, or as the cubes of their linear dimension (if the shape be similar).

Let V_1 and V_2 be the velocities of flow; W_1 and W_2 their weights in water; and D_1 and D_2 the similar dimensions of stones, which are just moved by the velocities V_1 and V_2 respectively.

Then we have:

$$V_1 : V_2 :: W_1 : W_2$$
$$:: D_1^3 : D_2^3$$

Thus, knowing the size and weight of a stone of a given form and specific gravity which will be just moved by currents of a certain velocity, we can calculate those for another stone of the same form and specific gravity which will be moved by a different velocity. However, this method is rather theoretical. A number of experiments has been made by different hydraulic engineers. Without going into further details, it will suffice to state the results of recent observations by Chief Engineer Sainjon in the River Loire. The results in English measures are as follows:

Velocity in feet per second,	1.64	3.28	4.92	6.56
Diameter of stone in inches,	0.40	1.60	3.90	6.70

The Mississippi and Missouri observations show that at the time when the inundation of the rising water takes place and spreads over the forelands, the bottom velocity is diminished and silt is deposited. As far as stability is concerned, a rocky bed is best; where the bed consists of gravel it is stable in an ordinary flow of water, but not stable in flood. When the bed consists of earth, the condition is such that it is just stable and no more, or permanently unstable. When the banks and the bottom are in the last-mentioned condition, the river channel constantly changes both in form and position, which is the case for rivers running in alluvial soil. A slight obstruction makes a straight channel curved. As soon as the bank is scooped a little bit, the curved part tends to become more and more curved on account of the centrifugal force, the line of the strongest current in such case being also toward the concave bank. The material excavated from the concave bank is silted upon the convex side, where the current is less rapid.

This noticeably took place in the Arakawa at the time of the flood in October, 1882. Thus, the concave part became more concave and the convex part more convex. This continues until the current comes into contact with hard material which cannot be scooped, or till the velocity is retarded and stability is established. It is for this reason that a curved part of a river must be avoided in selecting a bridge site. But in an unavoidable case, some means must be taken to make the channel permanent.

Although skew-bridges are generally to be avoided on account of the difficulty of construction and consequent amount of outlay, still in some cases advantage may be taken of a skew-crossing for allowing a certain amount of water-way. If a bridge be built at right angles to the direction of the stream, the piers, if built of masonry, will occupy about one-tenth or one-twelfth part of the cross-sectional area of the stream. This is objectionable in certain cases, because it produces a scouring action of the flood upon the river-bed. By deviating the line of the bridge more and more from the position of the square crossing, the disturbance of a stream by the bridge pier will gradually become less, and we will meet with such a case that in any square section, one and only one pier obstructs the current. This can be better answered by diminishing the thickness of the pier as much as possible, and the problem can be solved as follows:

The accompanying sketch (fig. 4) shows the arrangement for crossing a river by the above-mentioned principle. $A\,C$ and $D\,E$ are the banks of a river. $P\,Q$, $R\,S$ and $T\,U$ are the piers, and they are so arranged that the projections of the ends of two consecutive piers such as Q and R on the bank $D\,E$ are in the same point.

Let
B = breadth of river on square;
a = angle of skew;
b = breadth of pier on skew;
s = span of pier on skew;
n = number of spans;
$n - 1$ = number of piers.

Then we have
$$\frac{n\,s}{B} = \text{cosec. } a\,;$$
or
$$s = \frac{B}{n}\,\text{cosec. } a.$$
$$\frac{B}{n\,b} = \tan a\,;$$
$$n = \frac{B}{b \tan a}.$$

If $a = 70°$ (the limiting angle of obliquity),
$$\tan a = 2\frac{3}{4} = \frac{11}{4}$$
$$\therefore n = \frac{4}{11}\frac{B}{b}$$

In the above equation B is a constant quantity, being the breadth of a river; b, being the breadth of pier, depends upon the amount of traffic. The nearest larger whole number obtained from the above equation fixes the best number of spans, as far as the reduction of obstruction is concerned. But it will not be the number from the point of economy, the best number for which depends upon the difficulty of founding piers. The suitable length of span and the consequent number of piers should be selected to suit the nature of the particular circumstances.

V.—HEIGHT OF EDDY CAUSED BY PIERS AND OTHER OBSTRUCTIONS.

Having so far considered the subject of the resistance of materials to the flow of water, the next problem is to make an approximate computation of the new velocity and the increased head which will be formed when cross-section the river is contracted by the piers, abutments, and embankments. These obstructions will cause a *local* elevation of water. Like other hydraulic quantities, different hydraulic engineers give different solutions for determining the elevation of water produced in front of bridges and other obstructions. A solution given by Mr. A. Debauves is as follows:
$$y = \frac{Q^2}{2g}\left\{\frac{1}{m^2 w^2 h^2} - \frac{1}{W^2 (h+y)^2}\right\};$$
where
y = increased head or rise in feet.
Q = volume of discharge in cubic feet per second.
g = accelerated force of falling bodies.
W = original width of profile in feet.
w = reduced width of profile in feet.
h = mean depth of original profile in feet.
m = coefficient for contraction, the value of which depends chiefly upon the width of the piers, the form of starlings, and springing of arches.

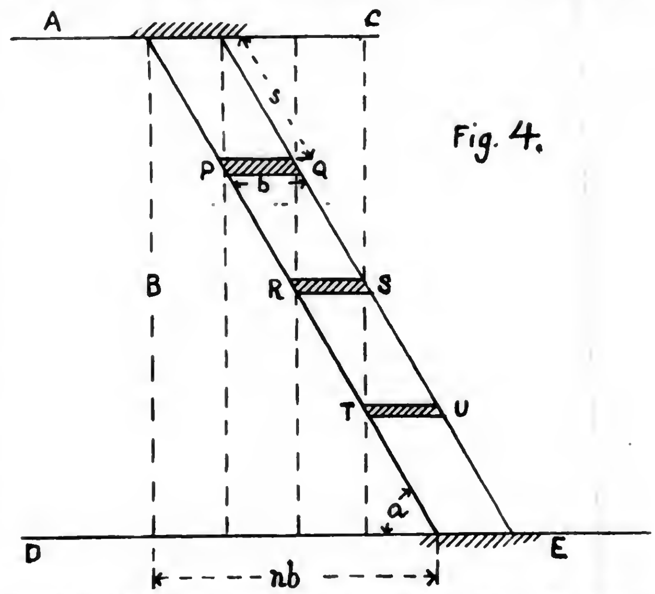


Fig. 4.

Although the values of m may not have been fixed with exactness, the following values will not cause any material error so far as the data are concerned.

$m = 0.75$ when the piers are terminated by a semi-circle or by acute angles.

$m = 0.90$ when the piers present an obtuse angle to the current.

$m = 0.85$ when the piers have square heads, the arches being large.

$m = 0.70$ when the arches are small and their springings are submerged in water.

The distance from the bridge to the point where the eddy extends cannot be accurately ascertained. But according to Mr. D. Aubuisson, in an ordinary river of nearly uniform regimen the elevation above the original slope line takes place as far up as expressed by the following equation:
$$D = 1.9 \times \frac{y}{s};$$
where D = distance in feet.
y = rise at obstruction in feet.
s = original slope.

These formulæ give only a rough idea of the increased head caused by the obstruction and the extent of it. An

instance may be given in connection with a railroad bridge over the River Tone in the Tokyo-Utsunomiya line. In February, 1884, when the bridge was to be constructed by founding 13 piers consisting of brick wells of 8 ft. in diameter, people in the locality feared that the local elevation of water and the extent of it would be great. But it is calculated that the local elevation is from 3 in. to 4 in. only, and it extends through the distance of 2,160 ft.

Having determined the value of y, the local elevation of water in front of the piers, we can calculate an approximate value of an increased velocity as follows:

Let Vi = increased velocity in feet per second.
V = original velocity in feet per second.
B = breadth of river in feet.
A = cross-sectional area of river before the bridge is built.

Then, supposing that the piers occupy 10 per cent. of the sectional area, it is reduced to $\frac{9}{10} A$ after the bridge is built, and we have

$$V A = V i \left(\frac{9}{10} A + B y\right)$$

$$\therefore V i = \frac{10\, V A}{9\,(A + B y)}$$

From this the corresponding bottom velocity can be calculated, and we can see whether the new bottom velocity will affect the river-bed or not.

Now the question arises, What will be the best way of making compensation for the increased velocity? One of the solutions of the problem is to make a local enlargement of the channel. But to maintain a large sectional area at a single point in a river while keeping the area both above and below small, without continual dredging, is against the physical nature of every river. Therefore, in bridging over a river, a sufficiently wide part must be selected, or else some means of reducing the obstruction, such as a skew-crossing, must be made.

(TO BE CONTINUED.)

THE TREATMENT OF TIES ON AUSTRIAN RAILROADS.

(H. Karplus, in the Vienna *Zeitschrift fur Eisenbahnen und Dampschiffahrt.*)

In taking up a subject which has already been much discussed by engineers, we propose in this paper not only to prove once more the excellent effects to be derived from the treatment of railroad ties and timber, and to show the excellent financial results obtained for a series of years, but also to add to previous testimony the latest results obtained in practice, and at the same time to point out the great economic value of the processes which lengthen the life of ties and other timber, and, by thus decreasing the yearly demand for renewals, lessen the draft upon the growing forests, prevent their devastation, and act indirectly but most favorably upon the meteorological and other conditions affecting the sources of the streams and rivers.

Both from the point of view of railroad management and from that of the general economic condition of the country, it is thus a pressing duty to recommend the adoption of preservation processes to all interests using timber largely, and especially to the railroads, which are now the largest consumers.

If we speak here chiefly of the treatment of ties, it is because they form the larger part of the consumption, because upon them the treatment has the greatest effect, and because there is attainable for them full and exact statistics extending over a series of years. It is self-evident, however, that any process of treatment which increases the resistance of ties to decay and atmospheric influences can also be used for other timber with the certainty that it will increase its durability under similar circumstances, and that no different arguments need be used to show that it is desirable.

As further proof we may mention the fact that the Post and Telegraph management has for a number of years used telegraph poles treated by preserving processes, and so far the results have been excellent. It may also be noted that on the lines of the Austrian State Railroad the timbers of the wooden highway-crossing bridges have been treated as far as possible, though in this case the use of these processes has been somewhat limited by the size of the boilers or impregnating vessels used, which are generally not over 10 meters (32.8 ft.) in length.

We are still in Austria fortunately so situated that in most places and neighborhoods timber and ties can be cheaply obtained. The only question to be considered by our railroad managements is, therefore, whether the treatment of ties, which costs money, is now profitable.

If we are now at a point where prices are so low, in consequence of an over-supply or other unfavorable circumstances, that the financial effect of the treatment of ties is only questionable, we must not forget that the only advantage to be gained—unless there is at the same time care taken to protect the remaining timber—that the fullest amount of work can be obtained from the ties in use, may be dearly bought in later years.

In practice we should, if we would follow a rational business course, preserve a proper balance between the average annual growth of our forests and the enormous demand, chiefly for railroad purposes, remembering also that this demand is largely for the better and more valuable kinds of timber. We cannot escape the belief that this law has been and will be continually more and more violated, if we refer to experience and have found that in many places the new growth of timber on land that has been cut over does not by any means keep pace with the destruction of trees.

In later years we have also taken pains to use certain kinds of wood for ties, which were unavailable for that purpose when not treated. Among these woods the beech is prominent. This application has shown such good results that in future, through treatment, an excellent use is provided for an abundant wood like the beech, and at the same time the more valuable woods are preserved for other uses. It may also be noted, as an indirect result, that for many years to come the value of land growing beech trees will be increased.

The treatment of timber has been in practical use over 40 years now, and much has been written on this subject, both in relation to methods and results. We might mention the names of Funcke, Buresch, Bischoff and many others.

In order to enforce these views the experience had on the Austrian railroads has been collected, and is shown in the accompanying table. In this table are shown the results obtained with ties of different kinds of wood treated and not treated, for periods varying from 13 to 18 years. The figures show the total percentage of the entire number laid which had been removed and replaced by new ones at the close of each year, and the results are very striking. Thus with untreated beech we find that no less than 5 per cent. had to be replaced the first year, 10 per cent. the second, and 25 the third, while by the end of the fourth year all the remaining 60 per cent. had been taken out. The same wood, treated by the sulphate of copper process, shows widely different results, so that at the end of the fifteenth year no less than 27 per cent. of the ties remained in the track. The results shown, extending over a long period, are very favorable.

If the details of the table are carefully examined, it will be seen that experience shows, almost without exception, that *the less the resistance which any wood in its unprepared condition opposes to decay, the greater is the comparative effect of preservative treatment.*

This result finds its explanation in the fact that in all the methods of treatment the soft woods take up during the process twice, and in some cases three times as much of the antiseptic preparation as the harder and closer-grained woods.

We may note especially, as shown in the table, that the effect of treatment on fir ties is excellent, and that the average life of preserved fir ties is much greater than that of the untreated oak ties. While with untreated fir more than half the ties were removed at the end of the eighth year, and all had been replaced in 12 years, at the end of

LIFE OF TIES ON AUSTRIAN RAILROADS.

Kind of Wood.	Treatment.	Number Laid.	TOTAL PER CENT. REMOVED AT THE END OF ——.																	
			1 Yr.	2 Yrs.	3 Yrs.	4 Yrs.	5 Yrs.	6 Yrs.	7 Yrs.	8 Yrs.	9 Yrs.	10 Yrs.	11 Yrs.	12 Yrs.	13 Yrs.	14 Yrs.	15 Yrs.	16 Yrs.	17 Yrs.	18 Yrs.
Beech	None	....	5	15	40	100	...	...	...	....	....	....	...	....	....	...	....	...	....	...
Beech	Sulphate of copper	1,871,200	....	1	1½	5	11	19	27	34	40	47	53	59	65	70	73	....	....	....
Pine and fir	None	100,000	1	3	10	33	75	92	100	....	....	....	....	....	....	....	....	....	...	....
Pine and fir	Chloride of zinc	32,910	....	1	2	4	12	21	30	38	47	56	65	73	82	90	....	....	...	....
Pine and fir	Creosote	19,450	....	...	...	....	0½	2	5	9	14	18½	27	38½	52	65	75	84	....	....
Fir	None	880,000	....	2	5	10	18	29	41	55	68	81	94	100	....	....	....	...	...	....
Fir	Chloride of zinc	491,400	....	...	....	....	0½	1	3	5⅛	10	15½	21½	28	34½	40½	47½	53½	59⅛	65
Fir	Creosote	83,600	....	....	....	....	0⅛	1	3	4	6	9	12	21⅛	26	30½	35	...	....	...
Larch	None	355,500	....	0½	1	1½	2	6	16	28	42	58	72	81	88	...	....	....	...	....
Larch	Chloride of zinc	970,735	...	....	...	....	0⅛	2	5	9⅛	17	26	34	43	52	62	73	....	....	....
Larch	Creosote	14,840	....	....	....	....	0⅛	1	3	5	9	14	21½	30	40	51	62	....	....	....
Oak	None	115,790	...	....	....	0½	1⅛	3	7	13	23	34	44	56	68	80	89	....	....	....
Oak	Chloride of zinc	529,564	....	....	....	....	0¼	0¾	1	4	9	17	24	31	37	41½	44	46	. .	....
Oak	Creosote	302,290	....	....	....	...	0¼	0½	1	1½	3	7	13½	20½	27	33⅛	38	41⅛	45	...

18 years no less than 35 per cent. were still in service. Or, contrasting the treated fir with the untreated oak, at the end of the fifteenth year there had been removed only 47½ per cent. of the former against 89 per cent. of the latter. This result is so much the better for the reason that a fir tie which has had preservative treatment costs less than an untreated oak tie.

It may be added that, as a result of the favorable experience had, the Southern Railroad has put in about 2,000,000 prepared beech ties, and that the State Railroad has, for four years past, been putting in a large number of treated beech ties, the results so far having been very good.

Other woods show excellent results. It may also be noted that the facts given in the table show that the common opinion that it will not pay to treat oak ties is without foundation. In addition to the financial gain there is the further advantage that the treatment of the oak ties not only makes the ties themselves more durable, but it also helps to preserve a valuable wood which is already growing scarce. The same may be said of larch.

We have thus shown in as condensed a manner as possible that on the Austrian railroads the results of the preservative treatment of ties have been exceedingly good, so that the statement of the observations made of the conduct of several million of ties over a series of years should be enough in itself to obviate the necessity of any further argument. It may be added that experience on German railroads shows equally good results.

At this point it may be suggested that the railroad managements, with the object of showing treated ties of the oldest dates, should have such ties taken from the roadbed and sections of them brought to a convenient place for exhibition. Such an exhibition would form an excellent pendant to the statistical table, and would be the more interesting as it would include soft wood ties of 16 and 18 years' endurance.

By the end of 1888 there will be on the Austrian railroads about 22,056,000 ties, of different kinds of wood. Of these about 7,683,000—35 per cent.—are treated, and the remainder—14,373,000, or 65 per cent.—are not treated.

Of the 7,683,000 prepared ties, 64.2 per cent. were treated with chloride of zinc after the Burnett system; 18.4 per cent. with creosote on the Bethel, Blythe, or Paradis, and 17.4 per cent. with the sulphate of copper process.

In recent years the cost of treating ties has been diminished by the use of portable apparatus and by the abolition of the permanent plants, thus doing away with the cost of carrying the ties to and from the place of treatment, and by the relatively lower cost of the apparatus itself does not put too heavy a charge on the smaller roads. Thanks to these circumstances, the cost of treatment is lower than for 15 or 20 years past, and now stands at hardly more than 22 to 30 kreuzer (8 to 11 cents), or at most 40 kreuzer (15 cents) per tie.

As to the introduction of iron superstructure in Austria, it is not to be thought of for a long time yet, partly because of the low price of wooden ties, but chiefly on account of the relatively high price of iron.

So long, however, as we can supply ourselves with wood, and can increase its durability as much as possible by preservative processes, we need not be troubled by any fear that we will suffer from a lack of ties or from the high cost of the introduction of iron or steel superstructure.

NOTES ON STEAM HAMMERS.

By C. Chomienne, Engineer.

(Translated from the French, under special arrangement with the Author, by Frederick Hobart.)

(*Continued from page* 504.)

CHAPTER XXIII.

THE MASSEY DOUBLE-ACTING HAMMERS.

The Massey Brothers, of Openshaw, near Manchester, in England, have made their works specially noted for the construction of small hammers, and have sold a considerable number of these tools, of a series of types, in all parts of the world.

It might be said that this firm has done more than any other to bring these tools into general use, by varying their designs according to the work which they were called upon to do.

All their hammers, the weight of which varies from 25 kilos. up to 20 tons, are distinguished by solidity of structure, and by the simplicity of their working parts. They are all double-acting, and are generally made automatic up to 500 kilos.; above this weight they are managed by hand.

The accompanying illustrations show a hammer of 200

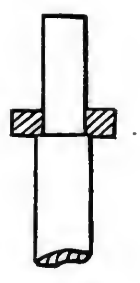


Fig. 81.

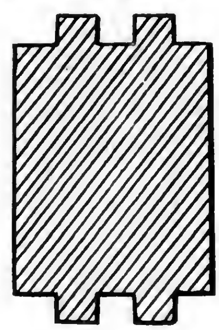


Fig. 82.

kilos., fig. 76 being a front view, fig. 77 an elevation, fig. 78 a plan, and fig. 79 a section on a larger scale.

There is nothing particular to note about the foundations; the anvil-block is independent, and the ratio between its weight and that of the working parts is 8 : 1; this ratio seems to us too small, as it should be at least 12 : 1, and by this higher ratio we would avoid the shocks which take place when the maximum stroke is used, and would better utilize the work produced.

The frame is in two parts, fastened by heavy bolts to the foundation plates and supports above the steam cylinders,

This arrangement allows the piece to be forged to be handled in every direction.

The hammer, which is well guided by the slides, is of wrought iron or of steel ; above 500 kilos. these hammers are generally made of open-hearth steel.

The rod and the piston are of steel and forged in one piece ; the lower part of the rod ends in a cone, which enters the hammer and is held by a semi-cylindrical key, the flat side of which is driven on a plane inclined to the rod, thus preventing all movement.

This hammer owes its success to the facility with which the stroke is regulated and the simplicity of its parts. throwing it back, and by means of the arm *K* lifting the valve-rod *D* and the valve *G*. This movement allows steam to enter the upper part of the cylinder, and thus causes the piston and the hammer to descend. The spring *L* throws back the lever *J*, the rod *D*, and the valve *G* to their former places in such a way that the movement of the hammer is carried on without shock or concussion.

M (fig. 77) is a lever at the side which serves to regulate the stroke of the piston ; when placed at *n* the lever *M* raises the lever *J* through the shaft on which the latter oscillates ; in this case the piston has only a short stroke, and if this lever is placed at *p* the piston rises to the full

Fig. 77.

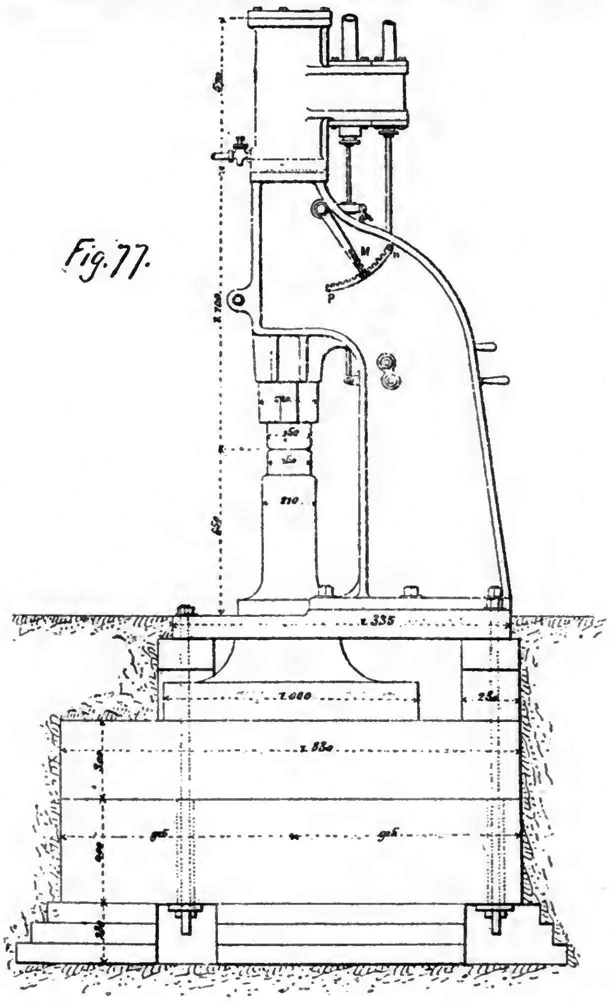
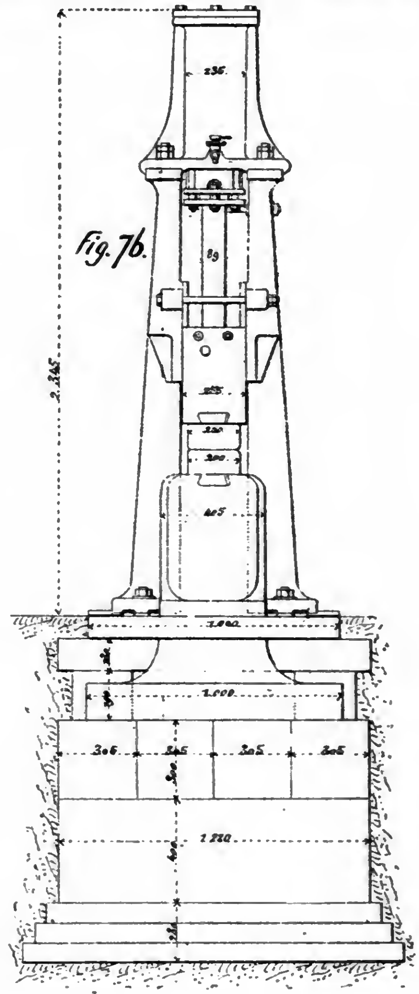


Fig. 76.



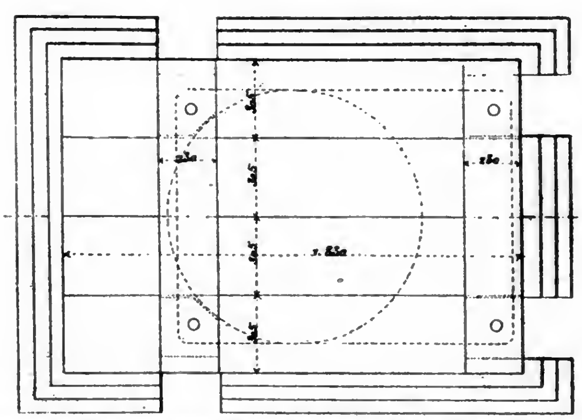


Fig. 78.

THE MASSEY 200-KILO. HAMMER.

Some of the details of its working parts are as follows (fig. 79) :

A is the steam valve worked by the lever *B*.

G is a circular balanced valve for distribution of steam ; it has no packing, as the expansion of the bronze of which it is made is greater than that of cast iron ; this is sufficient to make a tight joint.

D is the valve rod, which can be moved by hand through the lever *Q*.

I is a projecting lug or cam fixed to the hammer ; when the piston rises this cam slides along the curved lever *J*, height of the cylinder, and we can thus use the maximum stroke.

Q is a hand-lever, which is not used when the hammer works automatically, but when it is necessary to strike a dead blow with all the force available, this lever is thrown down by a short movement of the hand ; while it is held down the steam continues to press upon the piston ; this lever is thrown back at once by the spring *L*, when the hand is removed, but this spring should be stiff enough to keep the lever *J* always in contact with the cam.

If by chance the piston strikes the cover *F* of the cylinder

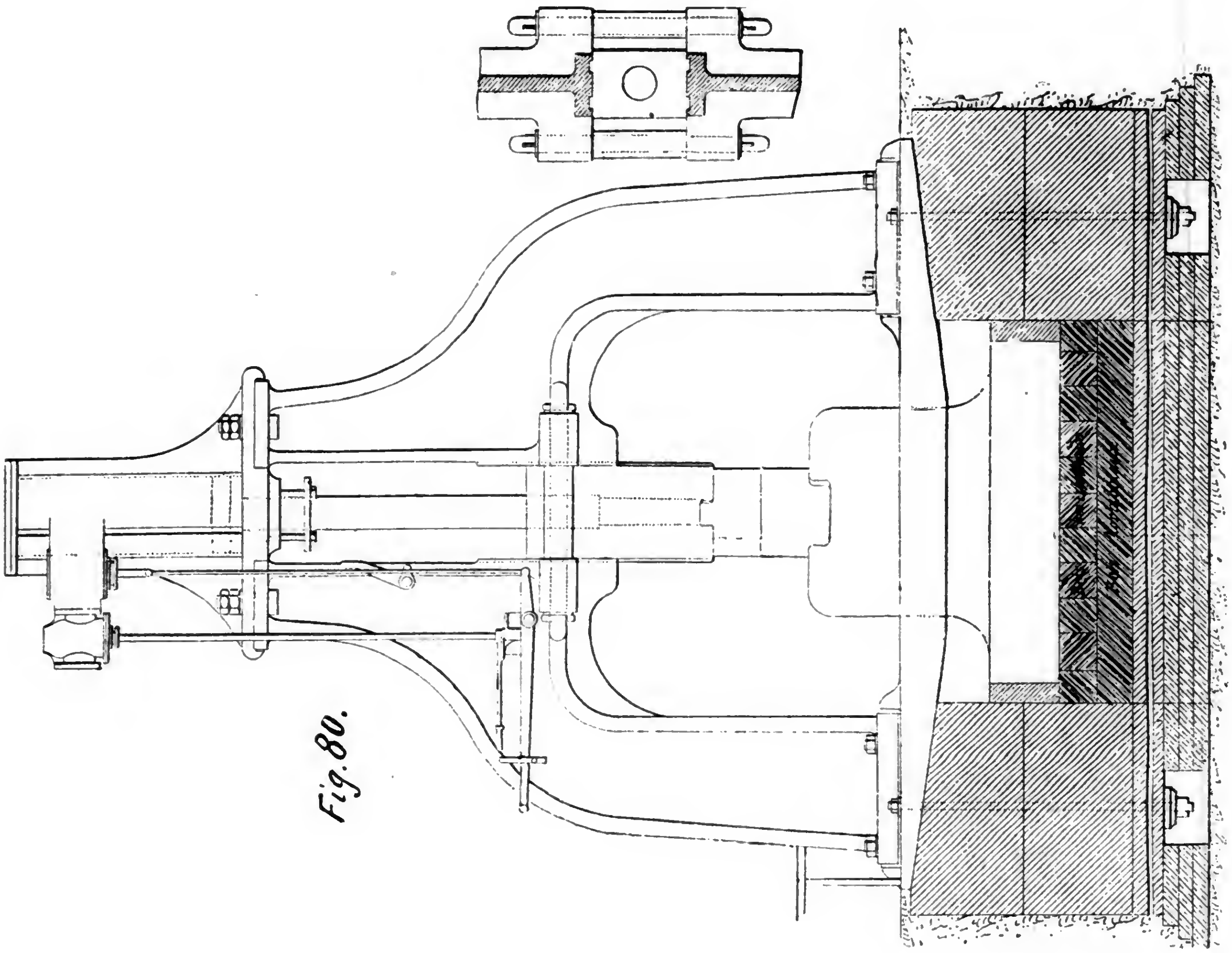


Fig. 80.

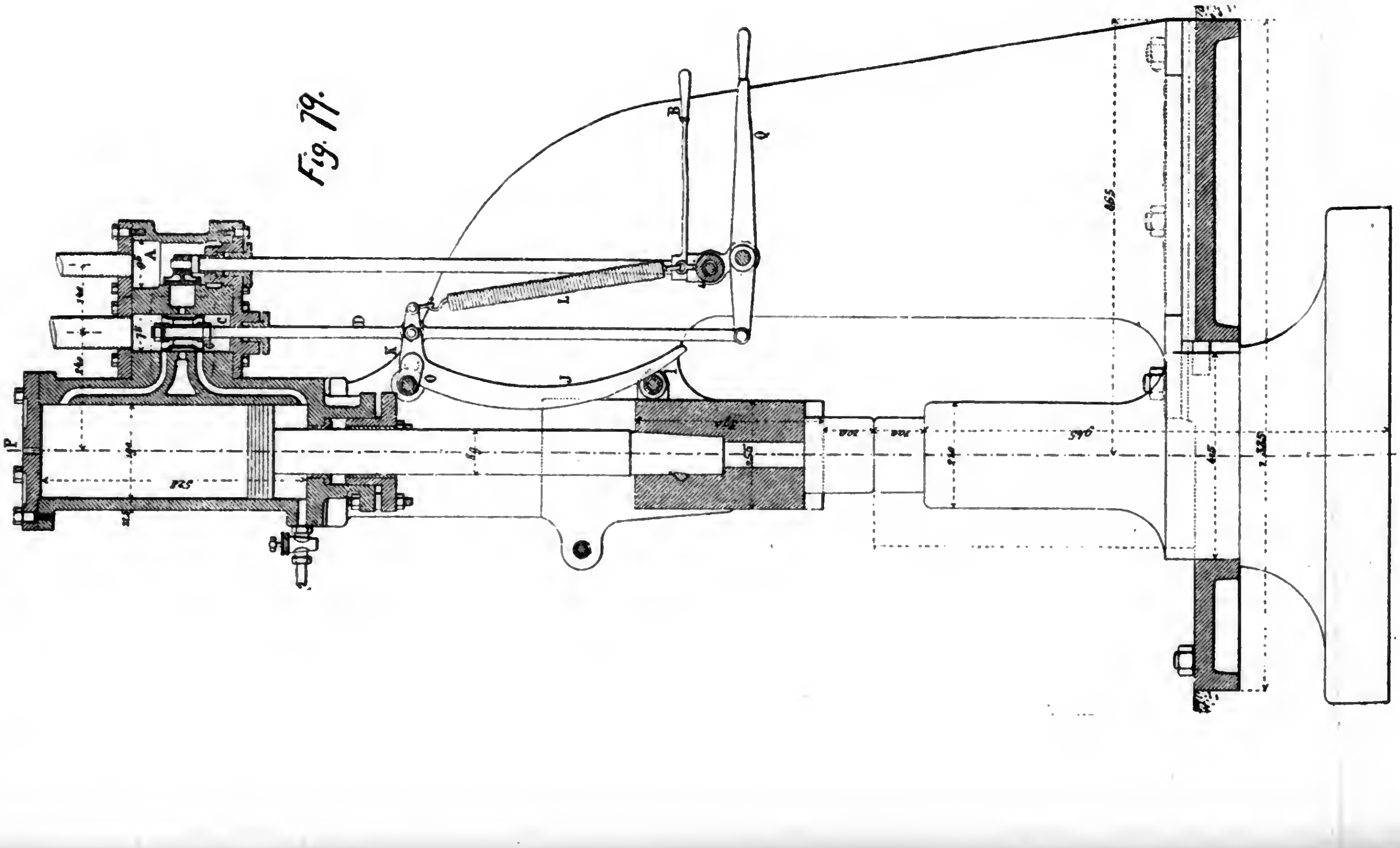


Fig. 79.

the trouble may be done away with at once by lightly raising the valve D upon its rod. It is sufficient for this purpose to place upon the ring C, shown in fig. 81, a washer $\frac{1}{3}$ mm. in thickness, or to change the ring by making it a little thicker. In the lower part of the cylinder is a small cock, which serves to carry off all the water of condensation.

The Masseys also build hammers of the same type, but with frames of wrought iron; each leg of the frame consists of two plates solidly braced together, which enables them at once to reduce the weight considerably and to increase the resistance, so that there is no reason to fear trouble caused by breakage.

Fig. 80 shows a hammer of 1,000 kilos. built by the same

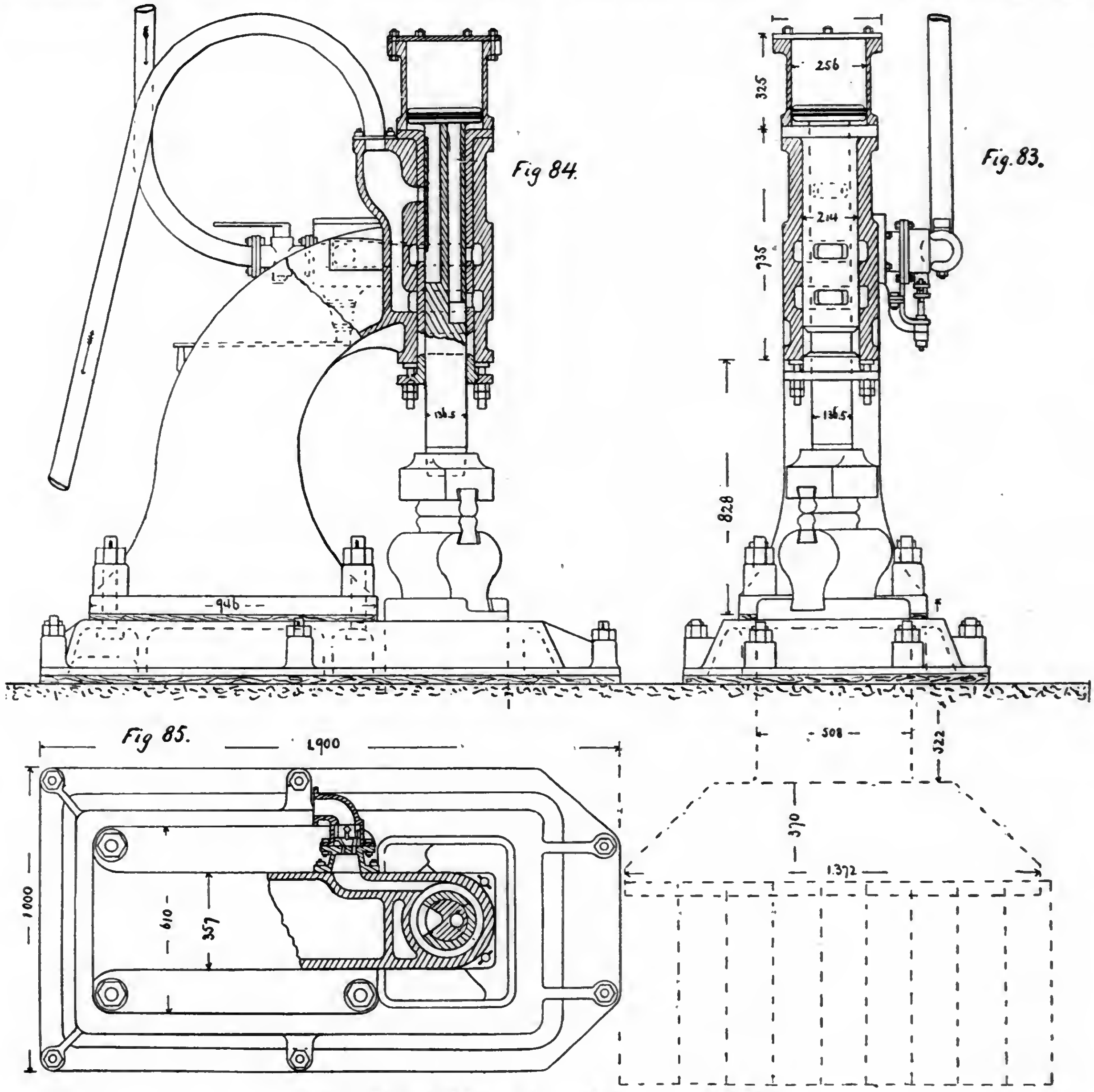
This type of hammer serves very well indeed almost all the purposes of the forge.

CHAPTER XXIV.

THE BRINKMANN AUTOMATIC HAMMER.

Figs. 83, 84, 85, and 86 show a hammer of 200 kilos., made by the firm of Brinkmann & Company at Witters-an-der-Ruhr, Westphalia; fig. 83 being a front view; fig. 84 an elevation, showing a section of the cylinder; fig. 85 a plan, and fig. 86 a full side view of the hammer.

The advantages of this class of hammer are found especially in the simplicity of the distribution of steam. The machinery for it is not subject to any disarrangement, while there are neither valves nor valve-rods. The distri-



THE BRINKMANN AUTOMATIC HAMMER.

firm; the valves are worked by hand and the hammer used to forge large pieces. In this hammer the form of the frame, while not quite so convenient for the use of the hammerman as that of the 200-kilos. hammer, has been chosen by preference because of its greater rigidity and resistance to the heavy shocks, resulting from the forging of pieces of large dimensions.

The joints of the foundation plates and of the frame are carefully finished and adjusted, and the legs of the frame are joined and braced below the slides by two heavy bolts.

In many of these hammers above 500 kilos. the guides are made with two shallow grooves in which the hammer works, thus giving a sufficient bearing surface without weakening the frames. A section of this hammer-block is shown in fig. 82.

bution is made by the piston-rod of the hammer itself, which has two longitudinal openings, one serving to admit steam below the piston and raise it, the other to admit steam above the piston and cause it to descend, and to increase at the same time the intensity of the blow. The stroke is limited by the slight lead given to the exhaust for the steam which acts below the piston, and to the admission of steam above the piston.

This hammer, as will readily be seen from a study of the drawing, is very simple, and can hardly get out of order.

The drawbacks to the use of these hammers are as follows:

1. They can only be used for short strokes and comparatively small power.

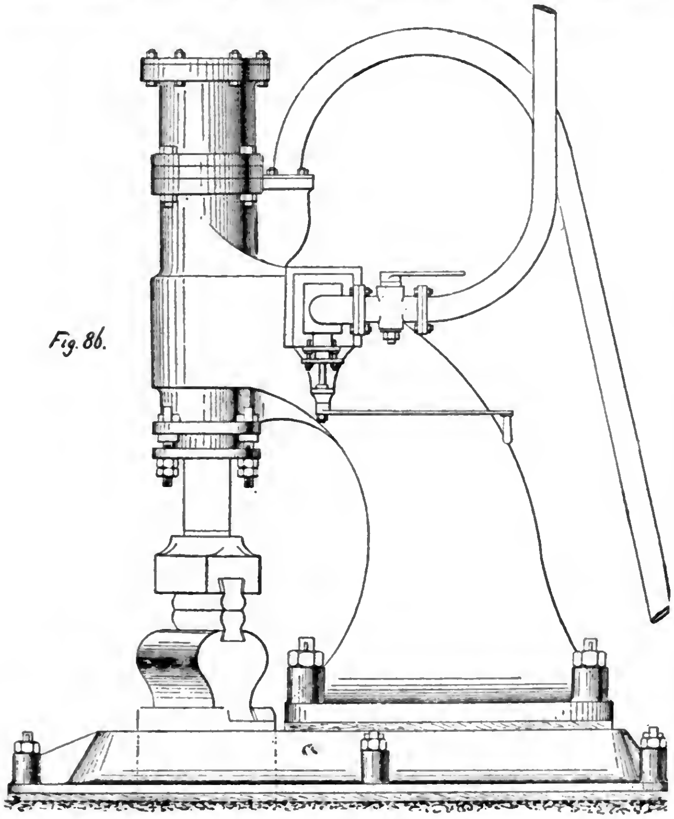
2. They cannot be used to give a quick stroke with a light blow, for with a higher pressure of steam the speed necessarily increases in the same ratio as the pressure above the piston, and the maximum blow is then reached.

3. The surface of the piston raising the rod should be at least one square centimeter per kilogramme of the weight to be lifted ; the pressure of steam should be at least 4 kilos., for below that pressure the speed of the hammer decreases very rapidly, allowance being made for the considerable amount of work absorbed by the friction of the stuffing-boxes on the rod itself. The packing of these is not easily kept tight, and the leakage is considerable ; for this reason the original packing or lining of the cylinder, which was of cast iron, has been replaced by one of bronze, which not only diminishes the wear on the steel rod, but also prevents binding in case the lubrication is neglected.

4. The use of steam is considerable in consequence of the large diameter of the piston.

In spite of these inconveniences, this hammer has its uses, chiefly for drawing out steel bars of small thickness ;

Fig. 86.



but it should be rejected for almost all kinds of forging properly so called.

CHAPTER XXV.

THE CREUSOT AUTOMATIC HAMMER.

This automatic hammer of 250 kilos. is shown in the accompanying engravings, fig. 87 being an elevation, fig. 88 a front view, and fig. 89 a plan. The steam cylinder is 0.300 meter diameter, with a maximum stroke of 0.500 meter.

The chief characteristic of this hammer is the method of the distribution of steam, which is made by a flat balanced valve. The motion is obtained from a square block fixed upon the upper end of the piston-rod. This block carries an arm with a pin, which works in a link forming the vertical arm or lever of a bell-crank, the horizontal arm of which works, through two small connecting rods, the rod carrying the distributing valve.

The intensity of the blow and the stroke of the hammer can be changed by a lever which moves a valve placed between the distributing valve and the port opening into the cylinder, the object of which is to reduce the section of the steam-port.

Steam is admitted to the steam-chest taken through a flat horizontal valve worked by a lever placed conveniently to the hammerman's hand.

The piston and the rod are made in a single piece ; the lower part of the rod, which enters the hammer-block, is conical, and is fixed in the block by a simple key.

The rod is extended above the piston by a circular section of the same diameter as the lower part, but there are on it two flat places, which, passing through the stuffing-box placed at the top of the cylinder, prevent any rotary movement.

The foundations of the hammer consist of a block of beton having a large surface and of two rows of oak timbers, upon which the frame rests. The anvil-block is a simple, rectangular truncated pyramid, resting in the central part of the hammer frame on two layers of oak timbers, and fixed in its proper position by wedges which are made of wood in order to lessen the shocks.

This hammer is very strongly built, is of careful construction, and serves very well for the lighter work of the forge, and especially for drawing out.

The dimensions of this hammer are as follows :

Diameter of cylinder	0.300 meter
Stroke of cylinder	0.500 meter
Stroke of steam valve	0.046 meter
Stroke of distributing valve	0.022 meter
Stroke of movable valve	0.020 meter
Pressure on piston, with steam pressure of 3 kilos	1.668 kilos.
Weight of hammer and rod	312 kilos.
Work produced (80 per cent.)	250 kilos.
Weight of anvil-block	1,012 kilos.
Total weight of hammer	8,960 kilos.

We have seen at the School of Arts and Trades at Aix a hammer similar to this, in which the automatic valve motion has been removed so that it works entirely by hand.

There has been placed at the top of the cylinder a safety apparatus, which consists of a hollow truncated cone, carrying on its upper end several rubber washers, on which the end of the rod will strike if the hammer raises too far. This modification was made by M. Coron, formerly Engineer of the School.

(TO BE CONTINUED.)

NEW ZEALAND RAILROADS IN 1887.

We give below the substance of a report of Mr. J. P. Maxwell, General Manager of the New Zealand Railroads, to the Minister of Public Works, for the financial year ending March 31, 1888 :

At the end of the year there were 1,758 miles of line open, against 1,727 miles in the previous year.

Interest at the rate of 2.3 per cent. has been earned on the cost of the opened lines, which is the same as for the previous year.

The expenditure has been reduced to £687,328, being nearly £3,000 lower than it was four years ago, and nearly £12,000 lower than in the previous year. Very stringent economy has been exercised to effect this, as there are nearly 300 miles more railway than in 1885. The means which have operated to allow of this economy have been chiefly the work of previous years—improved appliances introduced, saving labor in the shops ; better engines introduced to take heavier loads, effecting savings of labor thereby ; improvements in the roads due to better rails, sleepers, drainage, and a more permanent condition of the bridges gradually effected under maintenance ; improvements in the locomotives, leading to diminished consumption of fuel ; and finally the close head-office scrutiny exercised, and the intelligent and close application of the local officers.

On the average we are able to work with nearly 200 less hands than was the case in 1884-85.

It is to be regretted that the traffic has remained practically stationary since last year ; this is largely due to a late harvest, and to grain being held for more favorable sea freights. While the tonnage is slightly lower, the traffic work done is slightly greater than in the former year, the

average distance traffic has been carried being greater. The wool traffic shows a moderate increase. The fact that the live-stock traffic has not much increased is probably due to the fact that the export of mutton has curtailed the increase of flocks.

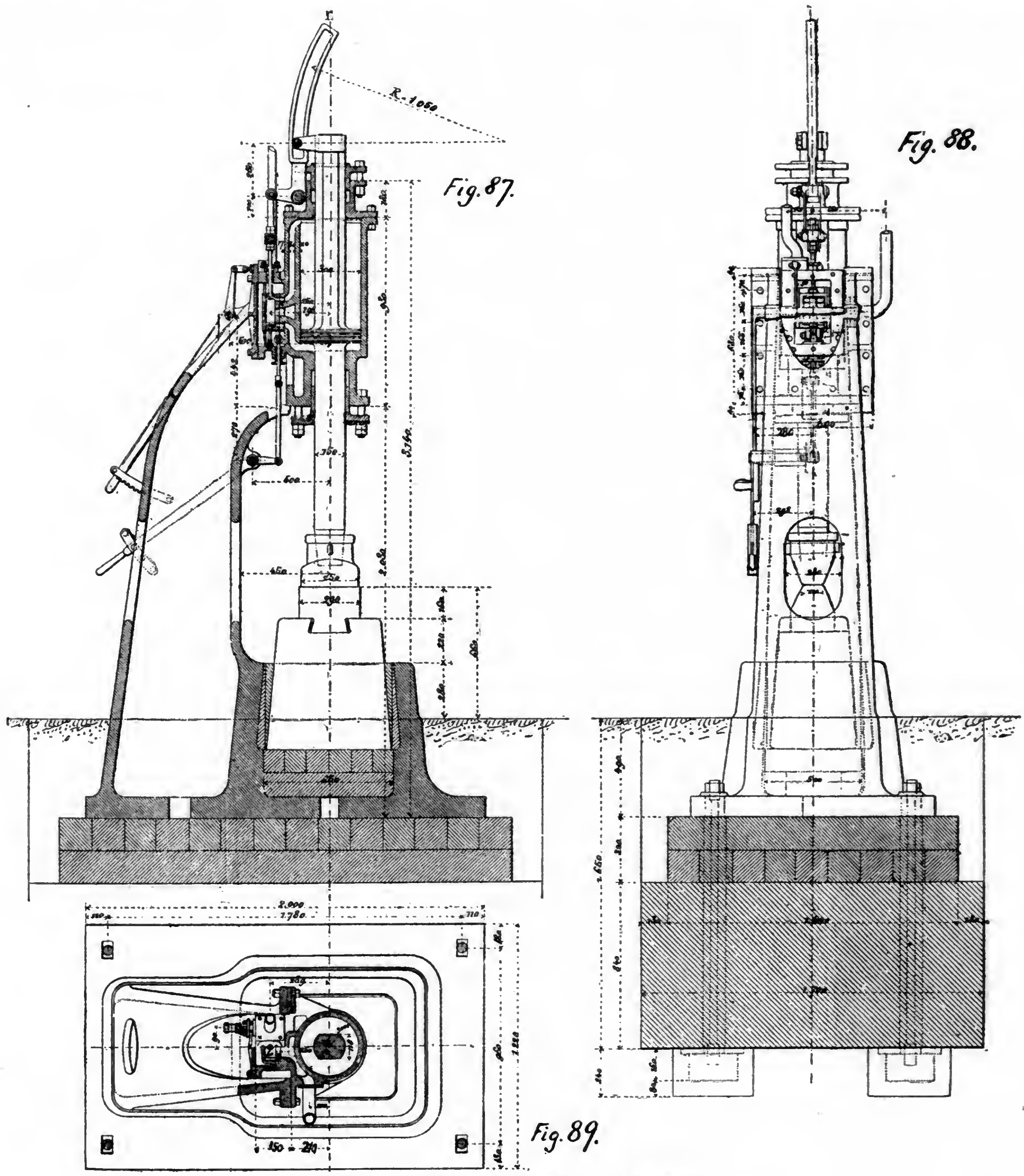
The net revenue has slightly increased. The gross revenue is lower than in the previous year. It is £50,000 below that of four years ago; this is mainly due to the numerous and large reductions which have been made in rates and charges during the past five years, the effect of which in reducing the revenue has doubtless been generally anticipated. It is to be borne in mind that the changes have nearly all been in favor of local products, so that producers have been benefited.

The total revenue for the year was £994,843; the working expenses £687,328 (69 per cent.) and the net earnings £307,515. These roads thus earned $2,750 gross and $850 net per mile.

The chief items of freight carried were 84,147 tons wool; 158,024 tons timber; 358,021 tons grain; 700,140 tons minerals; 42,067 horses and cattle, and 907,443 sheep.

The Railway Department now performs the duties of 135 public post and telegraph offices. It also deals with the goods traffic and collects the revenues of 13 ports, in addition to the purely railway work.

During the year 11 carriages and 92 trucks have been added to the rolling-stock. The practice of manufacturing all this work in the colony, except the channel-irons and steel tires, has been followed during the past eight years, and in that time more than £100,000 worth of new work in trucks and carriages has been turned out of the



THE CREUSOT AUTOMATIC HAMMER.

Government shops of a kind which had previously been imported.

A casualty occurred through a train being blown over during a northwest gale near the foot of the Rimutaka. Fortunately no one was injured. I have taken special precautions, since my return to New Zealand, to adopt, on this section, carriages permanently counterweighted below to prevent the recurrence of such an accident. A protective wind-fence has also been erected at the most exposed portion of this line.

	Locomotives.	Carriages.	Wagons.	Water-services.	Stations.	Private Sidings.
1880-81	197	414	5,805	155	467	174
1887-88	271	511	8,153	274	664	251

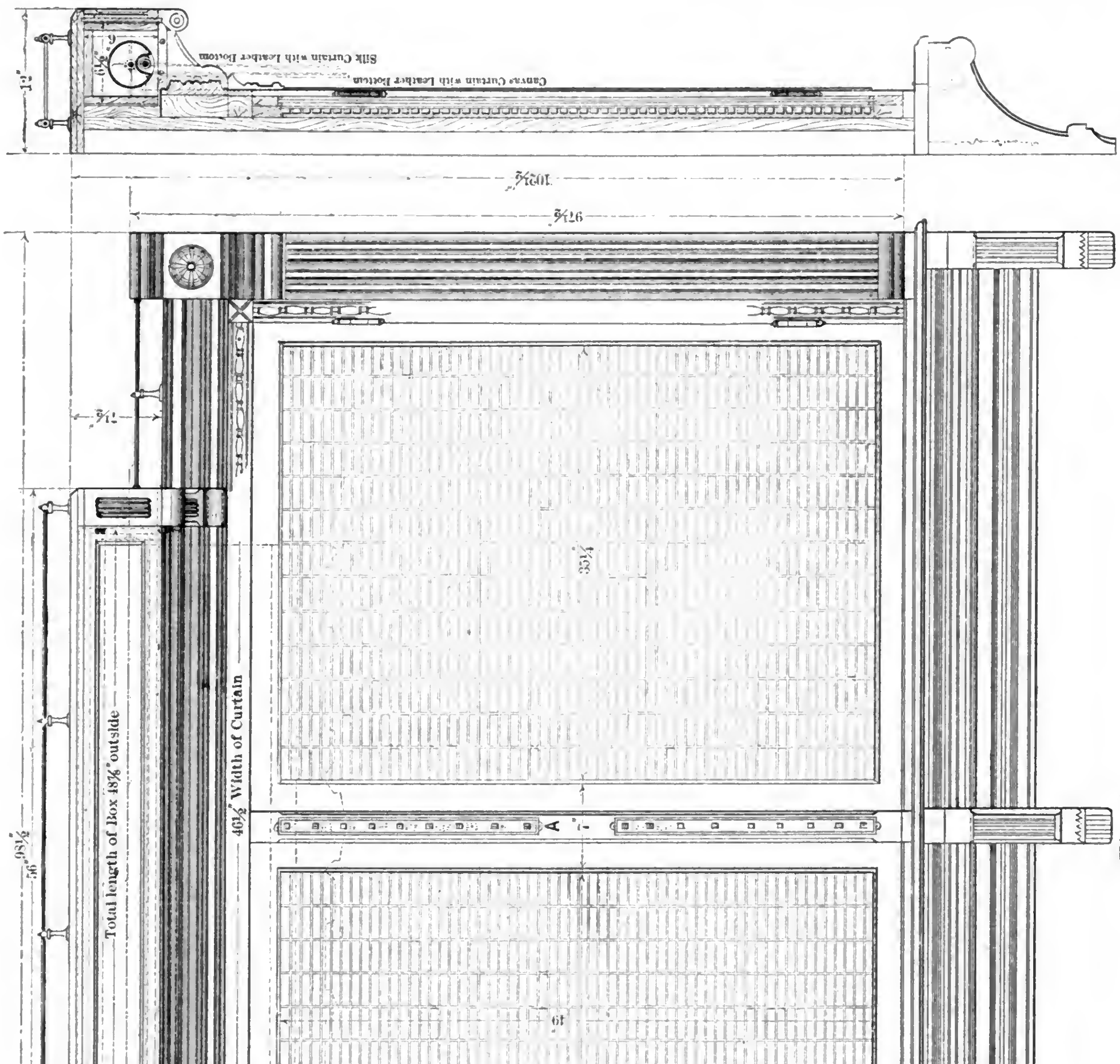


Fig. 2

Fig. 1

EQUIPMENT REGISTER CASE.

To show the large changes which have been made in the railways during the past eight years, and the increased responsibility of maintenance and general administration entailed by the additional stations, rolling-stock, appliances, and public accommodation, as well as by the greater length of the railways, and the large growth of traffic which has taken place, the following table is attached :

The number of the American type of carriages on the lines in 1880 was only 10. We have now 198 such carriages, which have been converted or built as new carriages in the colony during the interval. The comfort of the traveling public has been very materially improved thereby.

The manufacture of 10 locomotives in the colony by Messrs. Scott Brothers has been completed ; the engines

have run their test mileage, and are now in use, and are showing fair results.

After a careful trial, extending over a long period, of Winter's block-instruments, which had been supplied to us by the inventor, as adopted on the Madras railways, it was determined to substitute this system for the one previously in use here, as it gives a more complete safeguard against accident in working. During the past year the system has been introduced, and is working well.

The hydraulic cranes at Greymouth erected for the purpose of loading coal into steamers have been completed, and await the finishing of some filling and sidings to be started at work. This is the first introduction into this colony of the important system of hydraulic-crane-working on a large scale. The purpose of the cranes is to do the loading with the minimum of damage to the coal. Six-ton coal-boxes will be lifted from the trucks, lowered in the hold of the steamer, and emptied through a bottom door in the box, giving the coal a very small drop. It is possible that a system of hydraulic cranes would be of great advantage in the grain-sheds at Lyttelton and other places. Hydraulic-crane-working in England has been much extended of late years, and during my visit there, I was enabled to study its application. Our climate, being free from severe frost, is well adapted to the working of such plant.

EQUIPMENT REGISTER AND CASE.

The accompanying illustrations show a very convenient and well-designed register for locomotives and cars, their service and condition, which has been devised by Mr. S. H. Harrington, Chief Draftsman, and which has been put in use in the offices of the Superintendent and Assistant Superintendent of Motive Power of the New York, Lake Erie & Western Railroad at Buffalo and Cleveland. For compactness and simplicity it seems superior to anything of the kind which has yet come under our notice. The cuts represent the arrangement for the locomotive register, that for cars being only slightly different, as explained below.

Fig. 1 is a front view and fig. 2 a section of the register case, which is made to stand in the office ; fig. 3 shows on a larger scale the construction of the case and the size of the pigeon-holes ; fig. 4 shows, also on a larger scale, the schedule case, which is attached to the register case in

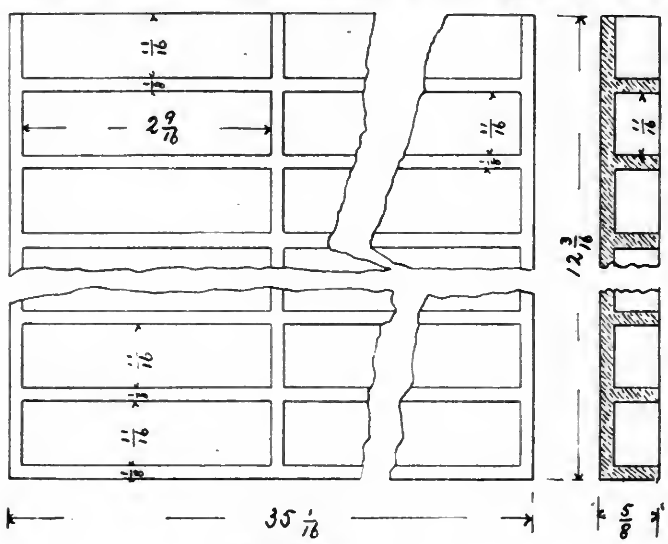
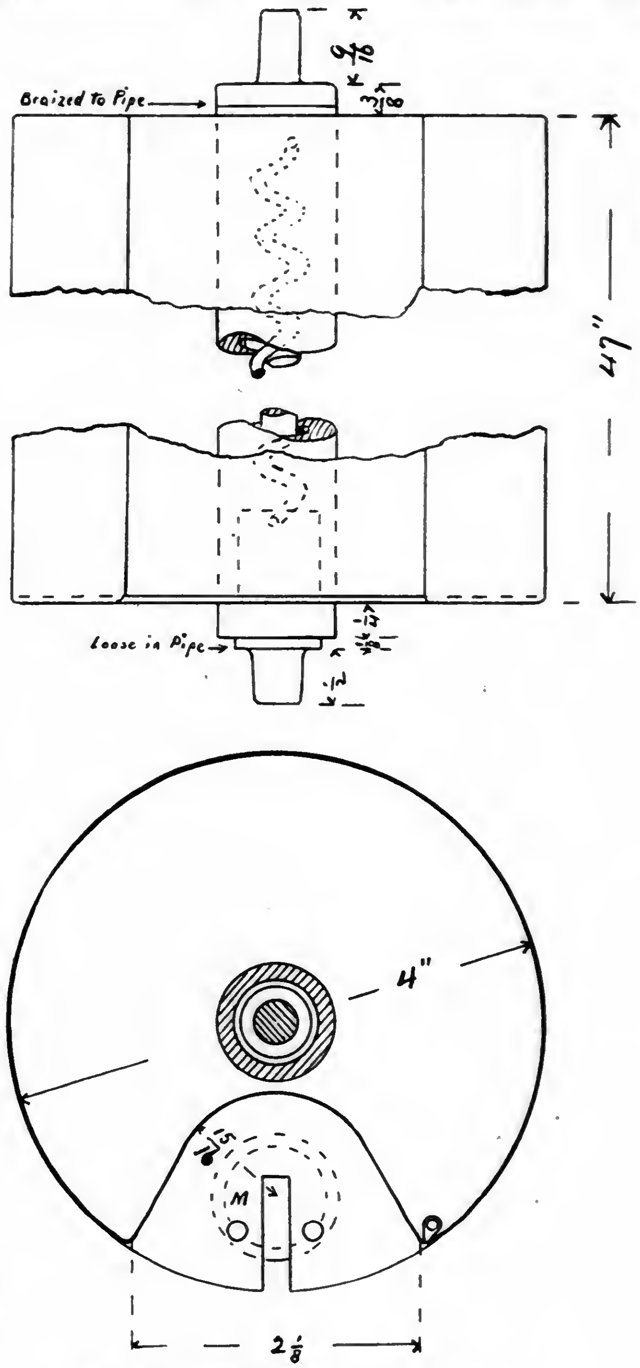


FIG. 3.

this instance ; fig. 5 is an enlarged view of a portion of the case showing the register in position (the blocks in this case being shown in black and white, instead of white and black, as they are in reality) ; fig. 6 shows on an enlarged scale a portion of the key-frame attached to the center of the register case, as indicated in fig. 1 ; fig. 7 is one of the large blocks for division names, shown also in fig. 5 ; and fig. 8 shows the faces of the register blocks, of full size, with the classification letters and service marks for engines.

All locomotive registers heretofore made have been complicated and difficult to keep on account of the multiplicity of parts required to give full information. In the present instance, however, they have been brought down to four separate pieces. The register case, it will be seen, has a number of pigeon-holes sufficient to provide one for each locomotive ; in each of these pigeon-holes are placed four cubes made of hard rubber and measuring ⅝ in. on each side. These blocks were made by the Goodrich Hard Rubber Company, of Akron, O., at a cost of $3 per hundred, so that the expense of starting the register is not excessive.

As already noted, there are four blocks in use for each engine, the first carrying simply the engine number ; the



M, is a ¾-in. Hartshorn vestibule roller.

FIG. 4.

second one carries the classification letters *A, B, C, D,* etc., which, of course, may be varied to suit the requirements of each road. In addition to these classification letters there are placed on the blocks marks, as indicated in fig. 8, one, for instance, showing whether the engine is provided with air-brakes, another whether it has driver-brakes, another of these with extension fronts, and so on. As in the case of the letters, this may be, of course, varied to suit the requirements of any road.

The third block in order shows the service in which the engine is employed, whether passenger, freight, working, switching, pushing, or so on, and these marks may all be placed on different sides of the same block, so that if an engine is transferred from one kind of service to another all that will be necessary will be to turn out a different face of the block. One face should be left blank, so that when an engine is out of service and in the shop for repairs this blank face may be turned outward, and the fact that it is not at work may be seen at once.

The fourth block shows the condition of the engine. This is indicated by colors, and therefore can hardly be shown in an engraving. The first face of the cube is white, which shows good condition; the second face, a grayish brown, indicates that the engine is in fair condition, requiring what are known on this road as Class 5 re-

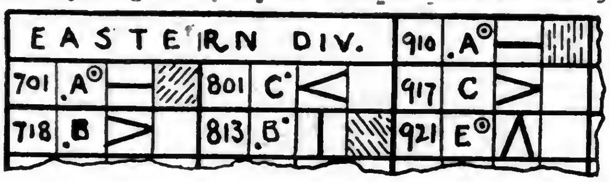


FIG. 5.

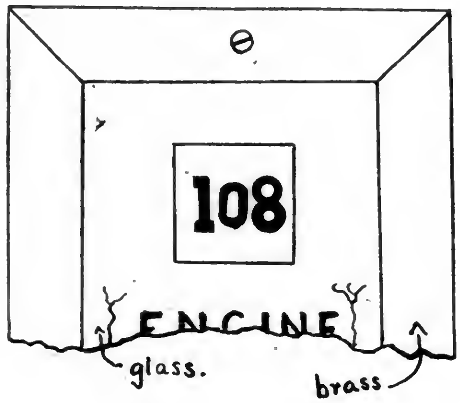


FIG. 6.

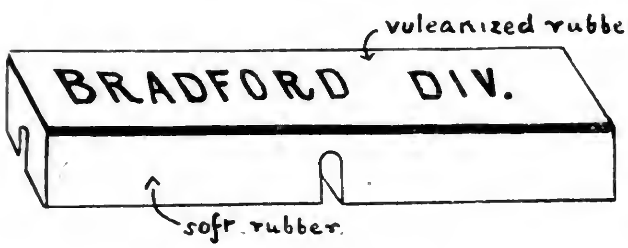


FIG. 7.

pairs—that is, costing less than $100. The third face, a light brown, shows that it needs Class 4 repairs—that is, costing from $400 to $500; a darker brown on the fourth face shows that Class 3 repairs, costing $500 to $1,200, are needed; the fifth face, a still darker brown, indicates Class 2 repairs, from $1,200 to $4,000, while a dead black, when turned outward on the sixth face, shows that the engine is in the shop getting Class 1 repairs, which will amount to over $4,000. These colors and classes can, of course, be arranged or altered as desired. Any change required by the daily reports can be made in a moment by simply taking out the block and replacing it with the proper face turned out.

A reference key, placed in the center panel of the register in a brass frame, with glass front, contains an explanation of all the blocks, and in its prominent place can be referred to at any moment by those using the register.

It will be seen that with a register of this kind properly kept the condition and service of any engine upon the road, and the division on which it is employed, can be seen at a glance, and the Superintendent can tell at once what engines are available for use, which of them are in the shop, etc. The additional information, which may be needed for reference, but which is not usually so often required—such as the general dimensions of the engine, the weight of drivers, heating surface, etc.—is kept in a book of blue-prints, 3 in. wide by 10 in. long, which has a diagram properly filled out for each class of engines. This book is kept in the pocket of the register below the doors, where it is readily accessible.

The roller or case attached to the register above, the construction of which is fully shown by the drawing, carries the schedule or time-table and performance sheets, which can be drawn down as required for reference, or can be rolled up out of the way when not needed, leaving the face of the register itself clear. All the schedules and performance sheets ordinarily required can be carried on this roller. The index or indicator on its face shows the order in which they are placed. While a very convenient addition, however, this is not a necessary part of the register, which can be made with or without it, as will readily be seen.

A register for cars can be made in exactly the same way, and one is in use on the same road. In the car register, however, the compartments can be made smaller, as only three cubes will be needed, showing number, class, and condition as to repairs. The service mark used in the locomotive case will not be needed, as passenger equipment has but one service. Here, as in the locomotive register, a fuller description of the cars can be kept in a book of blue-prints, in the pocket or drawer of the case.

In practice each Division Master Mechanic sends a weekly report to the Superintendent of Motive Power; in the office of the latter, where the engine register is kept, the proper corrections are made as the reports are received, and a duplicate of the register is made. Blue-prints of this are sent to the Vice-President, the General Superintendent, and to the Division Superintendents and Master Mechanics. These blue-prints are simply reproductions of the face of the register, showing the blocks in position, so that the engines on each division, with their condition, service, etc., can be seen at a glance, as well as by consulting the register itself. In this way, by the use of one engine register in the central office, with a blue-print chart and a few small rubber stamps, each officer of the road has full information in regard to the equipment under his supervision; the proper blue-prints can, of course, be quickly and readily made to any number required.

Any one who has had occasion to keep a record of locomotives or cars will readily see the convenience of an arrangement of this kind. Certainly it would be difficult to make one more simple or easily kept, while its details can without difficulty be modified to meet the requirements of any particular road.

ACCIDENTS ON INDIAN RAILROADS.

(From the *Indian Engineer*.)

In the recently published Returns of Accidents on Indian Railways for the Fourth Quarter of 1887, an attempt has been made to afford a better basis for comparison with the number of previous accidents than the method hitherto adopted permitted. That method was to compare the number and nature of accidents occurring in any particular quarter with those of the accidents which occurred in the corresponding quarter of the previous year. The Returns before us contain a comparison of the number of accidents occurring in the last quarter of 1887, with the average number in the corresponding quarters of *five* previous years, which shows the present state of affairs very much more satisfactorily than was possible with the former procedure.

Compared thus with the average of five previous quarters, the number of accidents to trains, rolling stock, permanent-way, etc., during the last quarter of 1887, shows a decrease of 64, or 10.21 per cent., against an increase of

2,534$\frac{3}{4}$ miles or 22.29 per cent., in the mean mileage open, and an increase of 1,370,805 miles, or 13.18 per cent., in the train mileage.

The more important fluctuations are noticeable upon the Rajputana-Malwa ; Northwestern ; Eastern Bengal ; South Indian ; Great Indian Peninsula, and Dibru-Sadiya railways, a marked decrease being apparent in every case, with the exception of the South Indian and the Dibru-Sadiya Lines.

In the number of casualties resulting from accidents to trains, etc., the quarter under review compares favorably with the Returns of the corresponding periods of five previous years. During the last quarter of 1887, three passengers and servants were killed, and eight injured, as against averages of four and nineteen, respectively, in corresponding periods of five previous years. The high averages observed in the latter case, are due to three collisions, which took place on the Eastern Section of the Eastern Bengal, the Sind, Punjab & Delhi, and the Southern Mahratta railways, on October 2 and 18, 1884, and November 16, 1886, by which 14, 12, and 8 passengers, respectively, were injured.

lated statement by which the accidents during the year 1886 are compared with those which occurred in England in the same year, which shows that the number of minor accidents is greater in India, but the casualties in India compare favorably with the results under this head from English working. Taking each 1,000,000 train miles run, the total number of accidents of all classes upon Indian railways amounts to 59.53, while the figure for the United Kingdom is only 6.91. It is gratifying to turn from this apparent reflection upon Indian railway working to the number of casualties, which we find to be for the year in question, 9 killed and 85 injured in India, against 12 killed and 696 injured in the United Kingdom. We notice in this comparative statement that the passenger mileage, which is stated as 3,894,076,609 for India, is described in the United Kingdom column as "not available." Those of our readers who followed our remarks upon the Defects of English Railway Statistics in our issue of April 25, will not be surprised at this omission, which affords a striking confirmation of a remark we then made, which seems worth reproducing in this connection :

"The main defect in English railway traffic statistics,

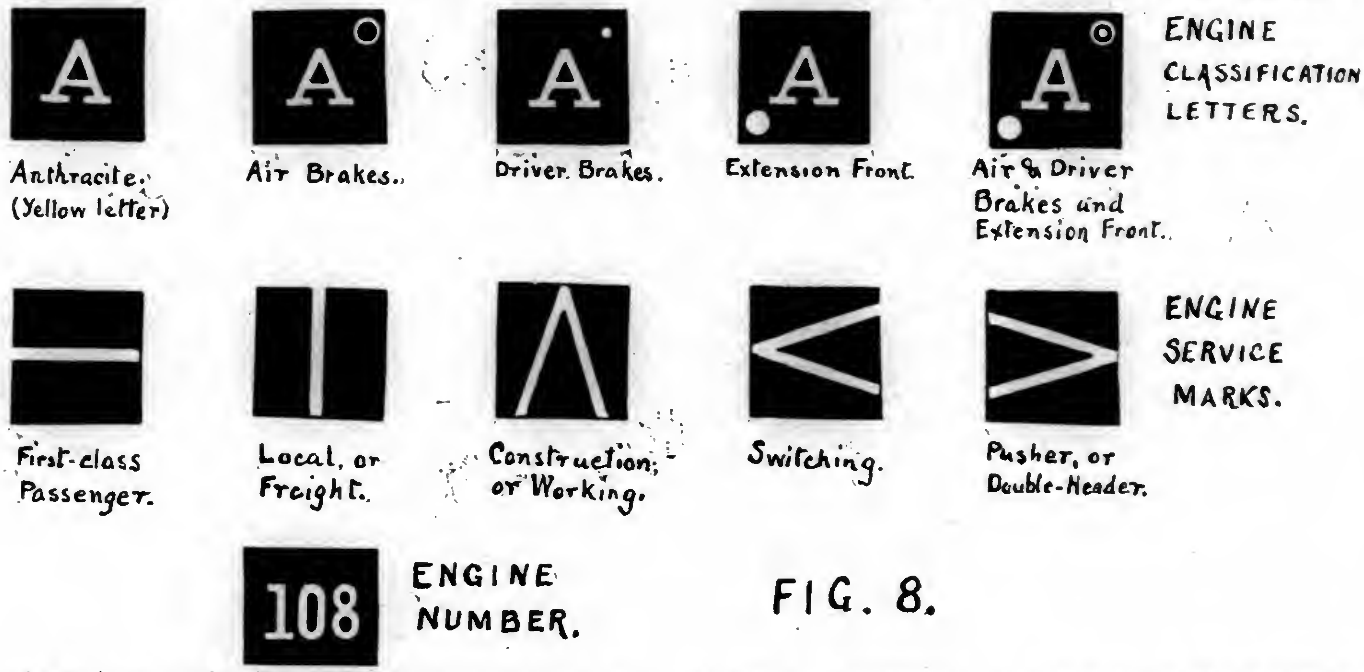


FIG. 8.

is that it is impossible for one to arrive at the cost of carrying a passenger and a ton of goods one mile, respectively, and without such information it is not possible to detect where the management is defective, and whether more business is being done at a cheaper rate.

"Until a different system of furnishing Returns is insisted upon by the Board of Trade, outsiders are unable to see how a railway can be most economically worked, and how the charges to the public can be most properly based."

As we have previously stated, the total number of accidents, in the last quarter of 1887, shows a decrease of 64, as compared with the corresponding quarters of five previous years, the figures being 563 and 627 for the two periods, respectively. A considerable portion of the decrease is due to the reduced number of cattle accidents, only 177 cases of trains running into cattle on the line being reported, as against 205 ; while the number of fires in trains has been reduced from 43 to 23.

The total number of passengers killed and injured, from causes connected with the working of trains, was greater during the period under review, than in the corresponding periods of five previous years, the figures being 15 killed and 27 injured, as against 10 killed and 36 injured. Of these casualties, however, only one passenger was killed, and one injured, by causes beyond their own control. The total number of persons killed and injured from causes connected with the working of trains shows an increase of 25 in the number killed, while the number injured remains the same. The total number killed during the corresponding quarter of five previous years was 88, of which number the increase of 25 constitutes a percentage of nearly 30, while the total train mileage was only increased from 10,401,557 to 11,772,362, or 13.18 per cent.

The Government of India, in their Resolution upon the Returns under review, observe with satisfaction that, with a large increase of open mileage and train mileage, there has been a considerable reduction in the percentage of accidents, as compared with corresponding quarters in the five preceding years.

A novel feature in the Return under review is a tabu-

THE LATEST ITALIAN WARSHIP.

(From the London *Engineer*.)

THE *Re Umberto*, launched at Castellamare in the presence of the Emperor William and King Humbert, is a steel twin-screw, deck-protected, barbette ship of 13,298 tons displacement, nearly as large as the *Italia* and the *Lepanto* of the same navy. As far as beam alone is concerned she is bigger than either of those leviathans ; and in this respect there is nothing that can rival her. Her dimensions are : Length, 400 ft. 4 in.; breadth, 76 ft. 9 in.; and her mean draft of water with all her weights on board is expected to be 28 ft. 8 in. She has no side armor at the water-line. A large amount of protection is, however, afforded to her by the construction of her bottom and sides, by the sub-division of her hull into a great number of water-tight compartments, and by a curved steel deck near the water-line. The ship's bottom is composed of

three skins, which form two water-tight spaces that are further sub-divided transversely. Experiments to test this mode of construction were made several years ago in Spezzia Harbor. A caisson, built up in a similar way, was moored, and a charge of 75 lbs. of gun-cotton was exploded in contact with it, and at a suitable depth. The two outer skins were ruptured, but the inner skin remained intact. Subsequently the inner one of the two spaces was filled with coal, and the experiment was repeated. This time only the outer skin was shattered. It may therefore be taken as proved that the construction of the *Re Umberto* affords protection against a considerable torpedo charge. The armored deck leaves the ship's side 6 ft. below the water-line, and curves upward until, along the middle line of the ship, it is but 2 ft. below the water-line. It is formed by a ⅝-in. steel plate, overlaid by a 2⅜-in. compound plate. Below this deck, and between it and the ship's bottom, there are over 50 water-tight compartments. Between the armored deck and the deck immediately above it there are 100 other water-tight compartments. If, therefore, water were to enter the ship either above or below the protective deck, its volume and evil effects might, with proper precaution, be strictly limited. The chief part of the armament will be carried in two barbettes, one forward and the other aft, on the middle line of the vessel. Each of these barbettes will be plated with compound armor 19 in. in thickness, placed at an angle of 24 degrees from the vertical. The ammunition hoists between the armored deck and the barbettes will also be armored, and the bases of the funnels will have substantial protection to a height of over 3 ft. above the water-line. Beyond this the vessel will have no armor.

The engines have been built by Messrs. Maudslay, Sons & Field, London. They are of the compound type, and are splendid specimens of marine engines; but it must be remembered that they were designed as far back as 1884. The following are the leading particulars of the engines of the *Re Umberto:* Four sets of compound engines, two sets being applied to work each screw propeller, each set having one high-pressure cylinder 47 in. in diameter, and one low-pressure cylinder 89 in. in diameter, with a stroke of 51 in., making about 100 revolutions per minute; diameter of screw propellers, 20 ft. Eighteen main boilers, 14 ft. 3 in. in diameter, 9 ft. 6 in. long, having altogether 72 furnaces, 3 ft. 2 in. in diameter, 6 ft. 4 in. long, with an aggregate area of grate surface of 1,444 square feet, and a total heating surface of 40,230 square feet. The working pressure of the steam is 100 lbs., and the indicated horse-power 19,500. It is expected that these engines will drive the ship at an extreme speed of 18 knots. The coal capacity of the vessel is 1,200 tons.

The armament of the *Re Umberto*, in addition to a ram, will comprise four 17-in. new model 104-ton Armstrong breech-loaders, two being mounted in each barbette; 12 6.1-in. Armstrong 4½-ton breech-loaders, carried in the batteries; six 3-in. guns and 10 machine and quick-firing guns, together with torpedoes. The so-called 104-ton gun —that is not its exact weight—has a total length of 40 ft. 9 in., the length of the rifled bore being 28 ft. 10⅝ in., and of the powder chamber 7 ft. 6 in. The number of grooves in the rifling is 80, and they have a twist of one in 50 calibers, or, in other words, of one revolution in 70 ft. 10 in. The full firing charge for the armor-piercing projectile is 900 lbs. of progressive Fossano powder; for common shell it is 600 lbs. The projectiles weigh 2,000 lbs. each. The bursting charge of the armor-piercing projectile is 32 lbs.; of the common shell, 60 lbs., and of the shrapnel, 5 lbs. The muzzle velocity of the gun, when fired with the full charge, is 199 ft. per second. The muzzle energy is 55,030 foot-tons—sufficient to raise the *Re Umberto*, guns and all, more than 4 ft. out of the water; and the projectile, at the muzzle of the gun, is capable of perforating 33⅓ in. of wrought iron. These heavy guns will be carried at a height of 28 ft. above the surface of the water.

The *Re Umberto* is to be completed for sea in 1892. Her design, which is also that of her sister ships, the *Sicilia* and the *Sardegna*, and of her kindred, the *Italia* and the *Lepanto*, has excited much criticism; and many competent judges have not hesitated to express an opinion that in the line of battle a vessel of this description would be dangerously out of place. Yet, if the *Re Umberto* is not useful as a battle-ship, it is hard to see what she can be useful for. The *Times* says that, writing in the August number of the *Jahrbücher für die Deutsche Armée und Marine*, Herr Spiridion Gopcevic denies her utility altogether. She is, he declares, neither a battle-ship nor a cruiser. She is not a battle-ship for the reason that her sides are entirely unarmored. She is not a cruiser for the reason that she does not carry sufficient coal. She is, moreover, too costly to be risked on cruisers' work. For the cost of a single *Italia* or *Re Umberto*, four ironclads, each of about 3,500 tons, might, he thinks, be built. Their united strength in artillery might equal that of the big ship; and if that were so, they would, he maintains, be together much more than a match for the monster. There would be four vessels—that is, four rams against one; and it is hard to believe that, even if she were successful in one or two cases, the large vessel would put out of action or sink all her opponents before being herself sunk. Nay, more, the single ship, in this comparison, labors under the considerable disadvantages of being unable to divide herself and to be in four places at once. She is the less able, therefore, to enforce a blockade. Her draft of water debars her from many ports and waters, her size from many docks. She takes four times as long as a small vessel to build. Whenever she is under repair, a fourfold strength is doomed to lie idle. Herr Gopcevic urges all this, and much more, against huge unarmored ships; and doubtless Italy has run some risk in investing so much money in them as she has invested during the last twelve years. Her navy is not, and never can be, strong enough to theoretically justify her in putting more than comparatively few eggs into one basket. Nevertheless the *Re Umberto*, for offensive purposes at least, deserves to be called a most formidable ship, if only because she will, when completed, throw a heavier weight of shot than any ship that has yet been built. Including all guns of 6-in. caliber and over, the gun-strength of the most heavily armed battle-ships of the naval powers is as follows:

	Weight of Discharge.	Muzzle energy of Discharge.
Re Umberto (Italian)................	8,960 lbs.	236,896 foot-tons.
Amiral Baudin (French)...........	5,950 "	124,770 " "
Victoria (British)...	5,176 "	132,832 " "
Deutschland (German)..............	3,864 "	66,530 " "
Tchesme (Russian)..................	4,988 "	123,772 " "
Krp. Rudolf (Austrian).	3,000 "	57,000 " "

This comparison, even if no other elements be taken, is sufficient to show that, whatever may be the weaknesses and demerits of the *Re Umberto*, she is a very dangerous adversary and a very remarkable ship.

RAILROAD SIGNALS IN EUROPE.

IN a recent number the *Revue General des Chemins de Fer* gives an interesting account of the progress and changes made during the last few years in the signal apparatus in use on French and other European railroads. This article, which is by M. Gossman, Engineer of the Northern Railroad, and which is fully illustrated, has been translated for our columns, and is given in part below:

I.—THE SAXBY & FARMER INTERLOCKING SYSTEM.

Every study of the application of an interlocking system to a station or yard rests upon this principle, that to each movement which can be made within the radius of action of a signal-station, there should correspond the change of the signal authorizing this movement. Thus, whether a locomotive passes along the main track or whether it goes upon a siding, this movement must await the opening of a signal, which can only be changed when all the apparatus on its line of passage occupies the proper position, the switches turned in the right direction and locked, and everything so arranged that the movement of the locomotive or train cannot be interfered with.

It follows from this that when, for a certain movement, it is necessary to open any given number, say n, of switches successively, there will be required, in order to display the

proper signal, as many distinct levers as there are switches plus 1, and the interlocking being necessarily different in each case, we would have to move, in order to open this signal, as many levers as there are directions to be taken —that is, $n + 1$.

Thus, at an ordinary junction of two tracks, the signal commanding the main track has always two levers, one corresponding to the right-hand, the other to the left-hand track, interlocked with the switch and its lock, in such a way as to secure the passage of the trains to the right or to the left, as may be desired.

In stations, and particularly in the case of a signal governing backing and shifting, the number of these levers increases rapidly, and it is not rare to find eight and 10 required for a single signal. As, moreover, the number of signals must be equal to that of the directions from which trains or engines can be moved, it will be readily seen that the number of levers becomes sometimes very great, although there may be really only a comparatively small number of switches or signals worked from a signal-station.

Thus, if we take as an example the case of the entrance into a large station, as sketched in fig. 1, into which three double-track lines, *A B C*, enter, and which has six platform tracks, *E F G H I J*, on each of which trains may enter, or from each of which they may leave for any of the main lines. These six tracks are crossed by two main switches, *M N O P*, each of which is furnished with switches, *T T T T*, at the intersection of each track, giving the freest possible communication. The inward-bound tracks are commanded by three stop-signals, *a b c*, the outward-bound tracks by three other signals, *a' b' c'*, and the platform tracks each by a signal shown at *e f g h i k*, making a total of 12 signals. Now, as each one of these would permit, when it is changed, the direction of a train upon any one of the other tracks, it follows that each inward-bound signal must be provided with six levers, and each outward-bound signal with three, making a total of 54 levers for the signals alone, without counting those which command the eight cross-junctions, *T T T T*, the four switches, *M N O P*, and the switch-locks with which they are provided. At such a signal-station we would very soon pass the point where 100 levers would be required—that is to say, we must have a very large cabin, and as the signalmen would have much ground to pass over, and many movements to make, their number would be very much greater than if the arrangements were simplified and the cabin made smaller.

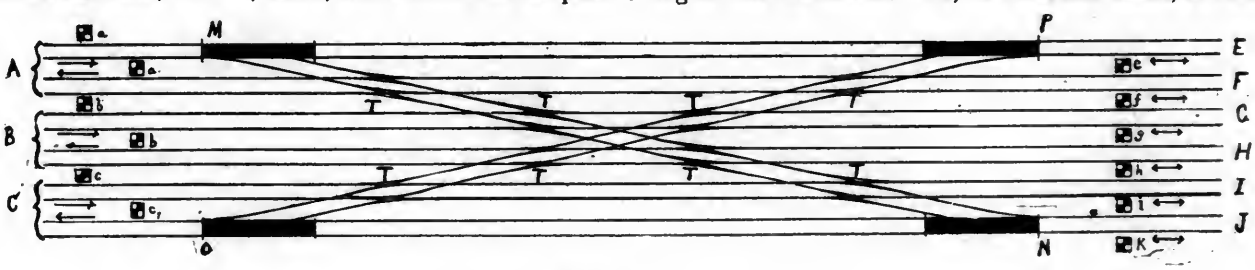


Fig. 1.

To express this in a general way, for a signal-station which commands the tracks, from m directions communicating with n tracks or siding, the number of levers to be placed in the cabin for the stop-signals only would be $2\,m\,n$, and when the signalman must, for a movement, which may be frequently required, change successively the last inward-bound and the first outward-bound signal, he would have to pass over in a hurry, besides the space occupied by his switch levers, a space equal to $2\,m\,n \times 0.13$ meter—that is, if we take the example shown in fig. 1, a total movement of 7 meters, which would necessarily occupy considerable time.

It is true that an attempt has been made to obviate this inconvenience by grouping together the levers which are most frequently used, thus violating the usual rule, which consists in placing in the signal-cabin the inward-bound signals at the left, the switches and switch-locks in the center, and the outward-bound signals at the right hand. Now, besides the objection that the arrangement mentioned above can only be adopted when the service is fairly uniform, it also presents the inconvenience of complicating very much the apparatus, since the same signal may have its levers placed at different extremities of the signal-cabin, and in that case the attachments of the wires or chains would cause an almost inextricable entanglement.

It therefore becomes necessary to secure elsewhere a solution to the question, and Messrs. Saxby & Farmer have found it in the use of what they call "selected levers," which permits them to simplify and to reduce largely the work required in fitting up a signal-cabin.

In principle a selected lever does not work any apparatus directly; it is simply intended to make a choice or selection of the direction to be given to a movement. It is therefore interlocked with the levers of all the apparatus which effect this movement in such a way that, in order to reverse the selected lever, it is necessary first to place in proper position all the signals and all the switches which permit the movement in question; that being done, and the selected lever reversed, the single lever opening the signal authorizing the starting of the train can be moved.

From this it results that the number of selected levers will be only that of the directions in which a train or an engine can be moved. As, on the other hand, the number of signals remains as before equal to that of the directions from which a train can be moved, and each of these signals has only one lever; as finally we must take into account the movements which can be made in both directions, the total number of signal levers, including the selected or directing levers, will be $2\,(m + n)$; if we compare this number with that which would be required in a case where the multiple levers were used, it will be seen that the ratio is the same as that of a number to its logarithm.

In applying the selected lever to the example which we have shown above in fig. 1, in which inward-bound trains may come from six directions and be turned upon six tracks, while the outward-bound trains may leave from six tracks and be turned in three directions, it will be seen that the number of levers would be 21 instead of 54—that is, much less than half the number. The movement required from the signalman would be only 2.70 meters; the loss of time and the amount of work would be diminished in the same proportion, and one signalman would be able to do the work which would otherwise require two.

It may be asked, and with reason, if the mental effort required from the signalman is not greater with selected levers than with the ordinary multiple levers. This question would be difficult to answer, partly because it is not easy for us to put ourselves in the place of a signalman, and partly because we cannot recall an example of a cabin in which the selected-lever system has replaced the old system, so that no account can be obtained from signalmen themselves. However, there is no doubt that if each movement is, as it were, simplified or materialized by a single lever, that idea can be more easily comprehended by a signalman than the thought that the lever is different according to the direction in which a movement is to be made. The only objection which a signalman could present is that there is one more lever to be changed with each movement; but to this it may be answered that the slight additional movement of the arms is compensated for by a great saving in the movement of the legs, and by the fact that it requires less effort of brain.

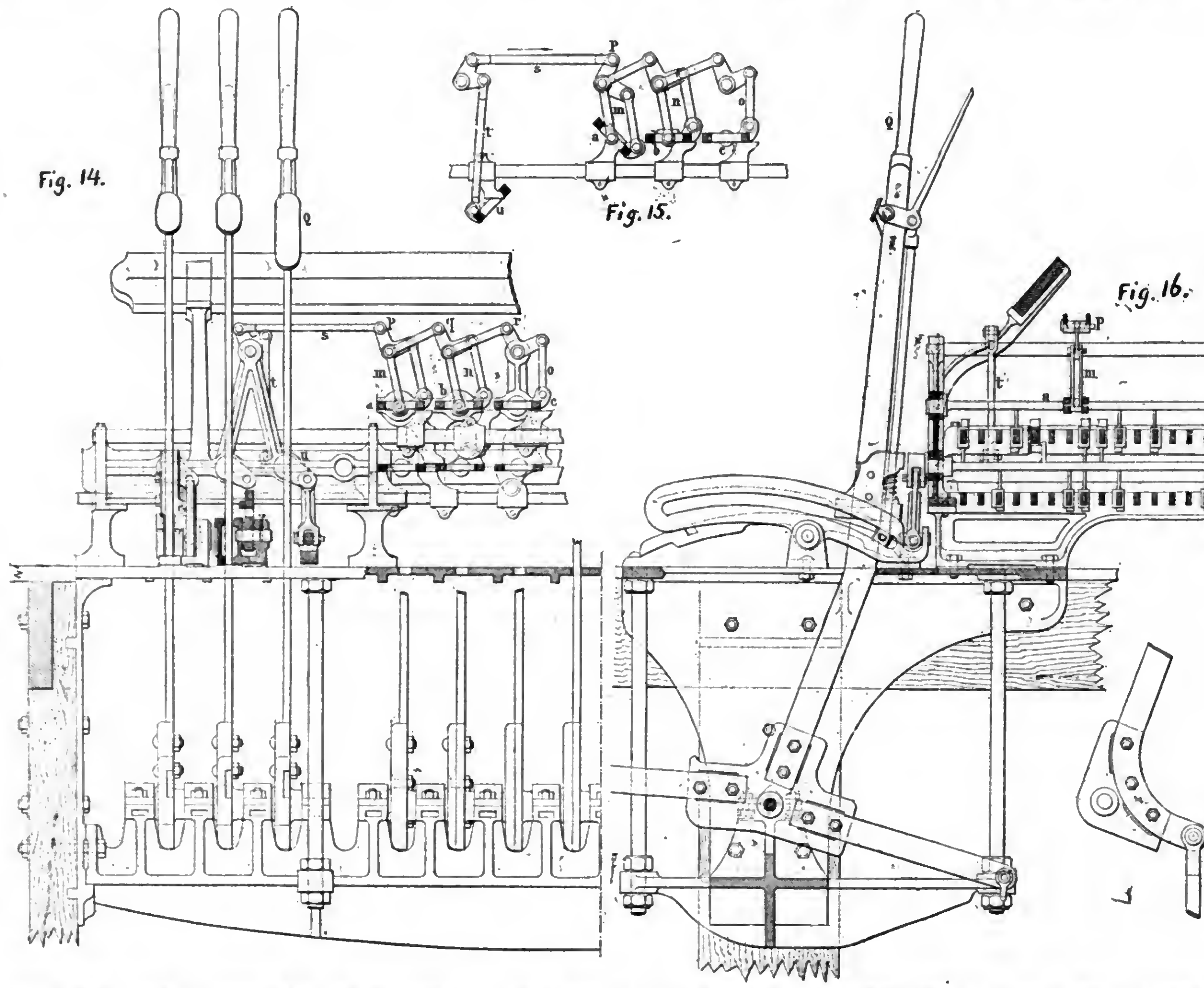
The introduction of the selected-lever system has therefore the effect of diminishing the cost, not in full proportion to the number of levers, but nevertheless in considerable degree, since the signal-cabin can be made smaller;

and also of decreasing the cost of maintenance, since the force of signalmen can be reduced and their time economized.

This combination, moreover, does not require any arrangement of apparatus which has not already been made for other purposes in the Saxby & Farmer signal-cabins; it requires only some additional interlockings, corresponding to a known formula, which, if we wish to generalize, can be solved by reference to the disposition designed and applied by M. Dujour on the Paris, Lyons & Mediterranean system. It will be sufficient to take a single example to show this.

6, 7, or 8, but permits only one of them to be reversed, so that it would not be possible to direct a movement out of two or three of the tracks at once.

The use of selected levers is not the only reduction which can be made in the number of levers in an interlocking cabin. Messrs. Saxby & Farmer have made arrangements which enable them to pass by the selected levers, and to replace them by interlocking combinations, which may be called "directing combinations." It is true that these new combinations have only been applied in a few cases where new levers had to be added to an existing cabin and space was lacking, but there is no reason why they should



In fig. 2 we have a track M, commanded by the signal 1, giving access to three tracks, A B C, according to the position of the switches 2 and 3, furnished with the locks 4 and 5. Let a b c represent the three selected levers, each corresponding to the arrival of a train on one of the tracks A B C. Suppose that we wish a train to enter on the track B, to reverse the selected lever b it will be necessary to prepare the track, change the position of the switch 2, to fasten the locks 4 and 5, and be sure of the position

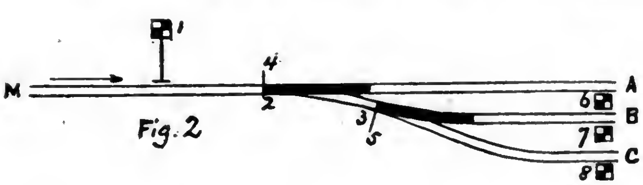


Fig. 2

of switch 3. All these necessities are realized by the interlockings $2N : bN$, $4N : bN$, $5N : bN$, $bN : 3N$, and finally to move the lever of the signal 1, $bN : 1N$. Inversely, suppose that we wish to move a train from the track B out upon the track M; there is only one selected lever for the three stop-signals 6, 7, 8 governing the passage out of the tracks A B C. The interlockings which govern this movement are as follows: $2N : mN$, $mR : 3N$, $mN : 6$, 7, and $8N$. This last additional interlocking, which is easily made, if reversed disengages either one of the three levers,

not be used for a new installation in such a way as to reduce the number of levers.

In fact, these directing levers are only used to move an interlocking-bar which fastens or frees certain levers, and their use brings us logically to the idea of suppressing the lever and keeping only the interlocking-bar. This requires for its realization only an arrangement by which a directing-bar can be moved in the proper manner.

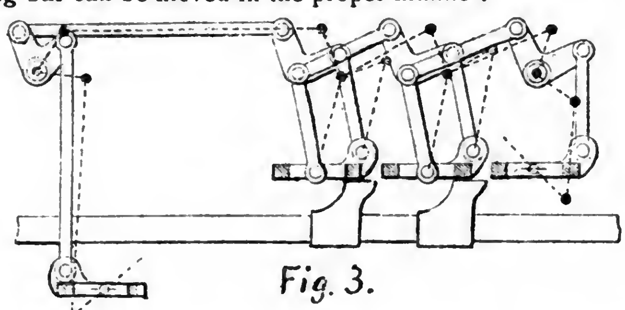


Fig. 3.

Take, again, the example given above in fig. 2; suppose a train arriving on the track M, which can be sent into either one of the three tracks A B C, and suppose there are three selected levers, a b c, each applicable to one of these three tracks. In place of the simple interlocking combination which we have shown above, there may be used a conditional relation of the form aN, bN, and $cN : 1N$—

that is to say, that in order to move 1 to give passage to the train, it is necessary to have first moved one or the other of the three levers *a b c*; but if instead of working a lever to change 1 we simply make possible the rotation of an auxiliary compound slotted lever, which produces the same effect, it is clear that we could avoid the use of the lever which moves this slotted lever. It would be sufficient to have three of these latter, as shown in figs. 14 and 15, each interlocked by simple connecting-rods depending from the apparatus which it is necessary to move in order to permit the entrance of the train upon the proper track. In the normal position these three slotted levers being interlocked and unable to move, the jointed parallelograms *m n o*—the right arms of which are connected by a crank with the axis of the slotted levers, while the left arms only work around that axis—cannot be changed; the points *p q r* are fixed and oppose resistance to the change of the cranks *s* and *t*, and the slotted lever *u*, with which the lever 3 is interlocked.

If, on the other hand, we move the apparatus—switches and locks—necessary to disengage the slotted lever *a*, for example, the parallelogram *m* can be changed, the point *p* can be displaced, while the lever *s* can be given a bending

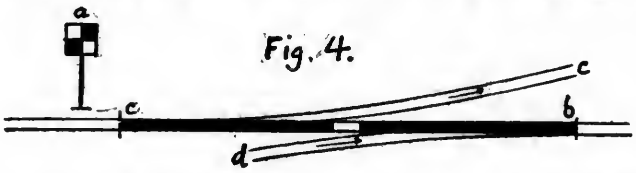


Fig. 4.

movement, the compound lever *u* is unlocked, so that the lever 2 can be reversed.

It would have been the same if instead of disengaging *a* we had moved *b* or *c*; consequently, the use of the three auxiliary compound levers *a b c* placed, so to speak, out of doors, is sufficient to give place for the directing levers and to realize the desired combination.

This arrangement has been applied in several cases, and especially at Cabin No. 2, at the Eastern Paris station. There is no doubt that, in compensation for the advantages which it presents—such as economy of space—there are inconveniences which always follow any complication in interlocking arrangements. Thus, in order to move the last slotted lever *c*, the three parallelograms shown in fig. 3 must be displaced, and from *u* to *c* there are no less than 18 axes of rotation which are brought into play, and there must result, unless the work has been very carefully done, a certain delay in the movement.

Since the time when we first described and discussed the theory of conditional interlocking, the question has been the object of much study, and we propose now to present a summary before indicating solutions applied in particular cases.

The theory of interlocking has been discussed at much length in the treatise of MM. Brame and Aguillon. Interlocking arrangements are classed by them into two groups: 1. Binary interlockings between two levers; these may be made simple, double, or special. 2. Conditional interlockings, generally between more than two levers, and almost impossible to analyze theoretically, so that we must limit ourselves to studying examples applicable to certain particular cases.

We may also mention a note published in our columns by M. Pichon some time ago on the General Solution of Ternary Interlockings, in which the Author observes with truth that most ternary interlockings are not conditional, and his conclusion is that if they are referred to a general type they can be analyzed and strictly defined.

As there is nothing to prove that a study, analogous to that which M. Pichon has undertaken in the case of three levers, will not give also a general solution for the interlocking of any number of levers, we propose to replace the erroneous term "conditional interlocking" by the term "compound interlocking," which may designate any system of more than two levers, whatever may be the form of the arrangement.

Lastly, in the second volume of their Treatise on Railroad Management, MM. Flamache and Huberti, examining the question of interlocking, complain—and not without reason—that our notation cannot conveniently be applied to all compound interlocking systems, and propose a new one, which, while it does not do away with the old, at least supplements it wherever it is not fully applicable. The signs proposed by these authors are as follows: $+$ means and; $-$ or; ( ) permits; a, lever a in normal position; b', b reversed.

Let us suppose, for instance, that the lever a can only be reversed if b is in normal position, c reversed, and d reversed; then we would write it thus:

$$(b + c' + d')\, a'$$

instead of the three expressions, $bR : aN$, $cN : aN$, and $dN : aN$.

Thus in a single expression we condense the different interlockings which can affect a lever; but we must not conclude that the only relation for which the expressions cited can stand is a compound one, for the translation of each of these relations can be obtained by binary or simple interlockings.

The following expression shows a compound interlocking noted on this system: $(a' - a + b)\, c$. This means that a normal or reversed, and b normal, permit c to be reversed.

This notation has the advantage that it can easily be used in cases of reciprocal action, and also that by it we can readily pick out similar cases.

The only criticism that can be made is that it rests upon an idea absolutely opposed to that of interlocking. In fact, the parenthesis marks ( ) are translated by the word permits or frees, which means that there is no interlocking; in our notation, on the other hand, the bar or colon has the advantage of representing graphically a real relation of interlocking, without obliging the operator to suppose that the movement is made in order to be able to write it on paper.

Thus the arrangement: "If aN, $bR : cN$ unless dN or eN," which means that we can reverse c, 1st, if a is reversed; 2d, if a, b, and d are normal; 3d, if a, b, and e are normal, would be written: $(a' - a + b + d - a + b + e)\, c$.

It may be asked whether the first notation, which consists simply in writing the relation as it is presented to the mind, as it would proceed in practice—only replacing the usual words by some abbreviations—is not more simple than the other, in spite of the advantage, more apparent than real, which the last has of expressing reciprocal actions clearly and rapidly. It is possible that we may

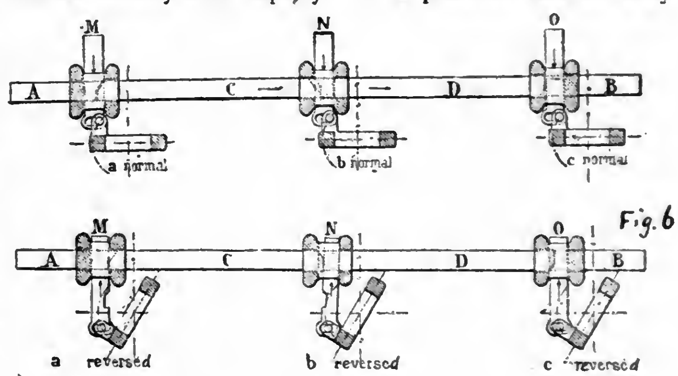


Fig. 6

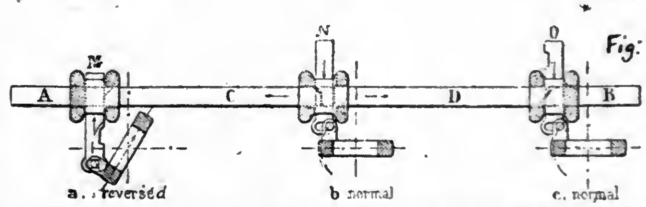


Fig. 7.

come to the conclusion, already suggested by MM. Huberti and Flamache, that it is best to use one or the other notation according to the case presented.

As examples of the application of compound interlocking systems we give below several apparatus recently installed in different yards to solve particular problems presented.

1. *St. Denis Yard, Signal Post No.* 1. The track, *c b*, fig. 4, is provided with a stop-signal *a*, which protects the point of the switch *b*, but which had to be placed before the switch *c*, because there was not room for it between the two switches. The object is to cover *b* safely without

delaying movement in the direction *c e*—that is, when *c* occupies its normal position, shown in fig. 4 by the black shading, the signal *a* can only be changed when the switch *b* is not turned toward *d*; but this interlocking relation must not continue when *c* is turned in the direction *e*. In their normal position the three apparatus are free, but if *b* is reversed, *a* becomes interlocked so long as *c* is normal, and is freed when *c* is reversed.

Messrs. Saxby & Farmer have solved this simple prob-

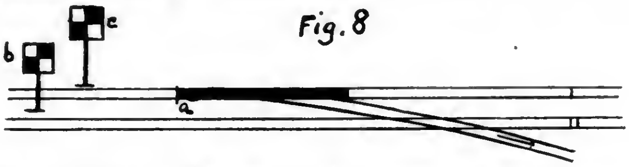


Fig. 8

lem as follows: The slotted levers depend on three levers, *a b c*, fig. 5, commanding, by means of pin-joints, three vertical flat bars, *M N O*, having each an inclined slot, by which they can move the auxiliary rods *C D* in a horizontal

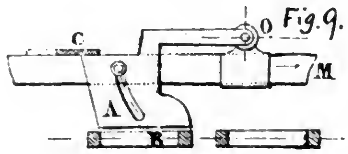


Fig. 9.

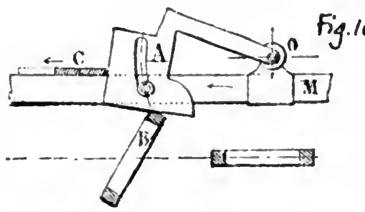


Fig. 10.

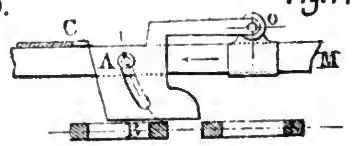


Fig. 11.

direction. Thus, if we pass from the normal position—fig. 5—to an intermediate position—fig. 6—by reversing the lever *a*—that is, by changing the stop-signal, we move the rod *C*, which enters the notch in the flat bar *N*, and prevents its descent in such a way that the slotted lever *B* is locked, and that the position of the switch *b* can only be changed while *c* remains in its normal position; but, as soon as *c* is reversed, play is given to the rod *D*, which was held between the narrow parts of the two flat bars, and nothing opposes the descent of the bar *N*, which takes only a slight displacement toward the right, when we reverse the slotted lever *b*—fig. 7—set free.

It will readily be seen that, reciprocally, if—fig. 5—we begin by opening the switch *b*, *a* will be interlocked as long as *c* is normal, and the flat bar *M* can only descend and free the slotted lever *a* when we move *c* to give play

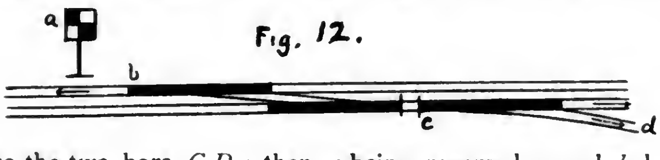


Fig. 12.

to the two bars *C D*; then, *c* being reversed, *a* and *b* do not interlock.

2. *Compiegne Yard, Post No.* 1. The same problem has been realized, without the use of the flat bars, which are open to criticism on account of their friction, in the following manner (fig. 8):

Here there are two parallel tracks, *I* and *II*, each commanded by a stop-signal, *b c*, and on the track *I* a switch *a*, giving access to another track, which crosses *II* on a level. It is necessary to interrupt movement on the track *II* only when the crossing is used—that is, *c* must interlock with *b* only as long as *a* is reversed.

For this purpose a slotted bar, *A*, fig. 9, connected with the lever *a*, is mounted on the bar *M*; *A* is jointed to the

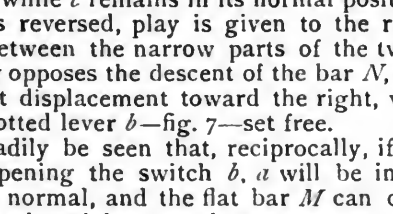


Fig. 13.

axis *O* and is guided by a pin moving in the slot, and has thus at once a movement of oscillation around *O* and a movement of translation given to it by the bar *M* moving horizontally. In the normal position shown in fig. 9 we can change both *b* and *c*, fig. 8, the slotted lever *B* being able to turn, and the plate *C* able to move within the limits shown by the dotted lines, without interfering with the movement of *A*; reciprocally, if those signals are changed, *A* bearing against the plate *C* prevents the movement of the rod *M*, and locks the lever of the switch *a*.

Lastly, if *c* is reversed and we change the position of the switch *a*, the plate *C* prevents the motion of *A*, and consequently the slotted lever *B* cannot be moved, and the signal *b* is then locked.

3. *Turcoing Yard, Post No.* 1. This is an example of a balanced interlocking arrangement, which solves the problem of an alternative combination in a different way.

In fig. 12 we have a stop-signal normally withdrawn, placed in advance of a cross-over switch *b*, beyond which is a switch *c*, furnished with a lock, the normal position of which is drawn back. It is necessary to lock the switch *c* only when a train runs over the cross-over *b* to go upon the track *c d*; as the lock has only a single hole, corresponding to the right of the switch, it is sufficient to make *a* interlock with the lock *a c*, but only when *b* is opened.

For this purpose the bars *a* and *c*, fig. 13, have shoulders *m* and *n*, and the bar *b* has a connecting-rod *k* jointed at the point *O* and furnished with a square head *t* having its side-faces beveled. In the normal position shown in fig. 13 the bar *b* can only move when *a* or *c* has been moved back so as to bring the shoulders *m* or *n* into the position shown by the dotted lines. The connecting-rod is then moved to one side or the other by the beveled face moving on the inclined shoulder *m* or *n*, and the bar *b* is unlocked. The signal for the cross-over can thus be given only after the lock is thrown—that is, after the switch *c* is opened; otherwise the signal *a* must be set at stop, which would forbid the movement.

(TO BE CONTINUED.)

Blast Furnaces of the United States.

THE *American Manufacturer* gives its usual monthly table of the condition of the blast furnaces on November 1, and says: "The totals are as follows:

Fuel.	In Blast. No.	In Blast. Weekly capacity.	Out of Blast. No.	Out of Blast. Weekly capacity.
Charcoal	75	14,005	93	10,594
Anthracite	97	28,442	99	25,692
Bituminous	141	88,273	86	41,713
Total	313	130,720	278	77,999

"Our table shows that the number of furnaces in blast was 313, compared with 310 on October 1—an increase of 3. The charcoal furnaces show an increase of 2, and the bituminous 3, but the anthracite show a decrease of 2, making the net increase 3. The weekly capacity of the furnaces in blast was 130,720 tons, compared with 129,710 tons on October 1. This shows a net increase of 1,010 tons—charcoal, increase, 1,022 tons; anthracite, decrease, 1,144 tons; bituminous, increase, 1,132 tons.

"The appended table shows the number of furnaces in blast November 1, 1888, and on November 1, 1887, with their weekly capacity:

Fuel.	Nov. 1, 1888. No.	Nov. 1, 1888. Weekly capacity.	Nov. 1, 1887. No.	Nov. 1, 1887. Weekly capacity.
Charcoal	75	14,005	80	14,145
Anthracite	97	28,442	125	36,720
Bituminous	141	88,273	148	94,982
Total	313	130,720	353	145,847

"This table shows that the number of furnaces in blast was 40 less than at the same date in 1887, the decrease being distributed as follows: Charcoal, 5; anthracite, 28; bituminous, 6. The weekly capacity of the furnaces blowing was 130,720 tons; at the corresponding date last year, 145,847—decrease, 15,127 tons."

CATECHISM OF THE LOCOMOTIVE.

(Revised and enlarged.)

By M. N. Forney.

(*Continued from page* 518.)

CHAPTER XIX.

ACTION OF THE PISTONS, CRANKS, AND DRIVING-WHEELS.

Question 524. *Is the whole of the net effective pressure which is exerted on the pistons communicated to the crank-pin?*

Answer. No, a part of this pressure is exerted to overcome the inertia of the pistons and other reciprocating parts during the first half of the stroke, while the back pressure resists their movement and helps to stop them at the end of the stroke.

Question 525. *How can we show the pressure which is exerted on the crank-pin?*

Answer. By first constructing a diagram similar to fig. 88, to show the pressure for any given speed which must be exerted on the piston during the first half of the stroke to accelerate it, and that which must resist it to bring it to a state of rest during the last half, and then laying off the net effective pressure, as indicated in fig. 243, on the line that represents the pressure which must be imparted to and is given out by the piston.

Thus a line, *E F*, fig. 331, should be drawn to represent the length of the stroke on the same scale as that used for *H D*, fig. 243. *E F* may also represent the line of atmospheric pressure. From the extremity *E* a perpendicular, *E N*, should then be drawn below *E F*, and another, *F L*, from *F* above *E F*. The centrifugal force of the reciprocating parts should now be calculated. With the same data and calculations given in Question 160 and its answer, we will have a centrifugal force of 14,660 lbs., which must be exerted at the beginning of the stroke to accelerate the piston. The influence of a connecting-rod seven times the length of the crank will increase this force one-seventh, as explained in answer to Question 165, so that it will be equal to

$$14{,}660 + 2{,}094 = 16{,}754 \text{ lbs.}$$

At the end of the stroke the force which will be exerted by the momentum of the reciprocating parts will be

$$14{,}660 - 2{,}094 = 12{,}566 \text{ lbs.}$$

If, now, we divide these forces by the area of the piston (which is 17 in. diameter) = 227 square inches, and it will give 73.8 and

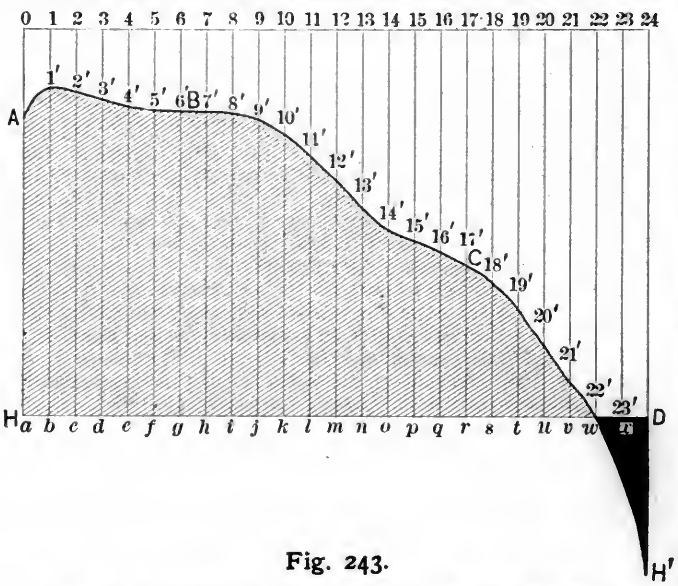


Fig. 243.

55.3 lbs. as the pressure per square inch which must be exerted at the beginning and end of the stroke to start and stop the piston. A distance, $E H = 73.8$, should then be laid off on the perpendicular *E N* below the atmospheric line *E F*, and a distance, $F D = 55.3$ lbs., above the atmospheric line. The point at which there is neither acceleration nor retardation of the piston is where the center lines of the crank and of the connecting-rod are at right angles. This is the case where the piston is still one inch ahead of the middle of its stroke, or has moved 11 in. If, now, we mark this point *g* on the atmospheric line *E F*, and draw the arc of a circle, *H g D*,* through the three points which have been laid down, the vertical distance of this line below *E F* will indicate the pressure per square inch at each point of the stroke which must be exerted on the piston at the speed named to accelerate it, and the distance of *g D* above *E F*, the pressure required to retard the piston. In other words, the vertical distances of *H g* below the atmospheric line *E F* represents the pressure on the piston which is needed to move the reciprocating parts alone during the first part of the stroke, and the vertical distance of *g D* above *E F* shows the pressure which they will exert on the crank-pin during the last half of the stroke, or the force which must be exerted to bring them to a state of rest. If we take the vertical distances *H A*, *b* 1′, *c* 2′, *d* 3′, etc., from

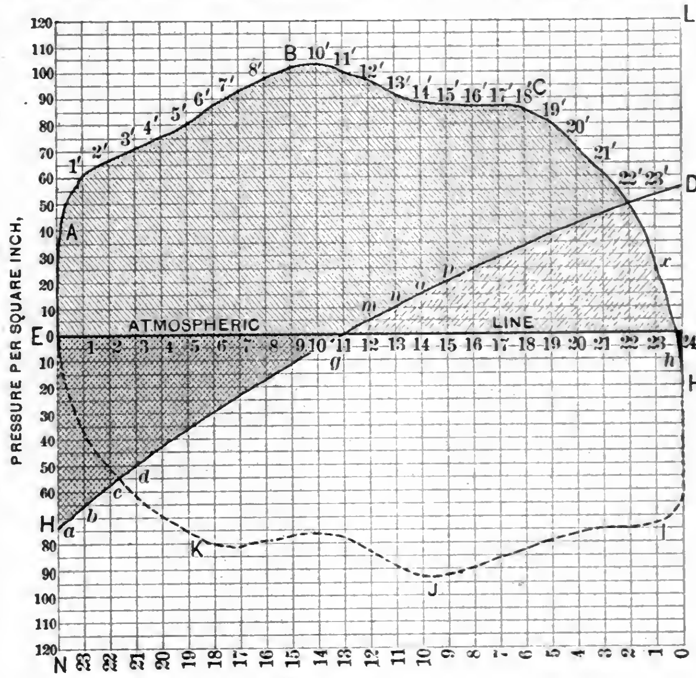


Fig. 331.

fig. 243—which represent the net pressure on the piston—and lay them off on the vertical lines above and from the curved line *H g D*, fig. 331, and draw a curve, *A B C x*, through their extremities, then the vertical distance of this curve above the atmospheric line *E F* will represent the net effective pressure which is exerted on the crank-pin. It has been explained that the distance of the curve *H g below E g* represents the pressure required to move the reciprocating parts *alone*, and therefore it must be deducted from the total steam pressure on the piston to get that which is exerted on the crank-pin. Consequently the distances 1 1′, 2 2′, 3 3′, etc., above *E D* represent the pressure on the crank-pin during the first portion of the stroke. As the momentum of the piston exerts pressure on the crank-pin during the latter half of the stroke—which is represented by the vertical distance of *g D* above *g F*—therefore the steam pressure on the piston must be *added* to this momentum and the pressure represented by the distances *m* 12′, *n* 13′, *o* 14′, etc., of fig. 243, are laid off above and from the curve *g D*, fig. 331, and are indicated by the same letters and numbers in both figures. The pressure exerted on the crank-pin during the latter part of the stroke, therefore, is equal to that of the steam acting on the piston *added* to the momentum of the piston, and is represented in fig. 331, by the vertical distances 12 12′, 13 13′, 14 14′, etc.

The back pressure on the piston indicated by the area shaded black in fig. 243 is laid off below the line *g D*, fig. 331, and is *deducted* from the momentum of the piston.

Thus, at 23 in. of the stroke this pressure is measured by the line 23′ *x*, fig. 243. This distance is therefore laid off below the line *g D*, fig. 331, and is indicated by the same number and letter as in fig. 243. The pressure represented by the distance *D H′* of fig. 243 is laid off in the same way on fig. 331. By extending the curve *A B C f* through *x* and *H′*, its distance above the line *E F* will therefore represent the pressure on the crank-pin during the whole of the backward stroke, and its distance below *g F* the back pressure exerted on the pin.

The length *a A*, *b* 1′, *c* 2′, etc., of the vertical lines in the shaded area *H E A B C f* represent the steam pressure in pounds per square inch on the piston. Their length *a o*, *b* 1, *c* 2, etc., in the area *H E g* represents in the same way the portion of the pressure which must be exerted on the piston to move and accelerate the reciprocating parts from the beginning to the middle of the stroke. The area *g D F* represents the horizontal pressure exerted by the reciprocating parts during the last half

* This curve is not exactly an arc of a circle, but such an arc is a sufficiently close approximation to the actual curve for the present purpose.

of the stroke. The area $D f H$ shows the net back pressure on the piston near the end of its stroke, $g f h$ the net effective pressure exerted by the momentum of the reciprocating parts during the last half of the stroke, and the area $E A B C f F$, above the horizontal line $E F$, shows the net effective horizontal pressure exerted on the crank-pin. A similar diagram has been made for the forward stroke of the piston, but has been laid off *below* the lines $E g F$ and $H g D$, and is represented by the dotted line $H' I J K E$.

QUESTION 526. *In what way does the momentum of the reciprocating parts modify the effect of the pressure of the steam when it is worked expansively?*

Answer. It equalizes the pressure on the crank-pin during the early and latter part of the stroke. This will be seen if the diagram figs. 243 and 331 are compared. Fig. 243 shows that the steam pressure on the piston during the early part of the stroke is much greater than during the latter part, whereas the effect of the reciprocating parts, as shown in fig. 331, is to reduce the pressure on the crank-pin in the first half of the stroke and increase it in the last half.

QUESTION 527. *What is meant by the rotative effect of the steam on the crank?*

Answer. It is the pressure which the steam exerts at right angles to the center line of the crank, the direct effect of which is to turn the crank.

QUESTION 528. *How can the rotative effect of the pressure on the crank-pin be ascertained?*

Answer. This can be done by first constructing a diagram similar to fig. 331 for any given speed, point of cut-off, pressure of steam, or dimensions of engine. Then let $A B$, fig. 332, represent a horizontal center line drawn through the center of the cylinder and center O of the axle. From O as a center draw a circle, $O' L B K$, whose diameter is equal to the stroke of the piston, to represent the path of the center of the crank-pin. From the front dead-point O', with a distance equal to the connecting-rod, lay off the mark A on $A B$, which will be the position of the center of the cross-head pin at the beginning of the stroke. Now, for any position of the crank-pin, such as C as a center, and with the length of the connecting-rod as a radius, describe a short arc a, intersecting the line $A B$. Then the distance $A a$ will be equal to the movement of the cross-head pin, which is equal to that of the piston from the beginning of the stroke. Then draw $a C$ to represent the center line of the connecting-rod when the piston has moved the distance $A a$. From a a distance, $a b$, should be laid off equal to the horizontal pressure, in pounds per square inch, exerted by the combined action of the steam pressure and momentum of the reciprocating parts. Now, if this pressure is exerted against the end of the connecting-rod $a C$, which at this point of the stroke is inclined to the center line $A B$, its inclination will cause an upward vertical pressure to be exerted at a, which must be resisted by the guides. If, then, $A b$ is drawn equal to the horizontal force, and $b c$ parallel to the vertical line $a d$, and if from the intersection c of $b c$ with $a C$ a line, $d c$, is drawn parallel to $a b$, we will have a parallelogram, $a b c d$, of which the center line $a c$ of the connecting-rod forms a diagonal, and the side $a b$ is equal to the horizontal force, $b c$ will be equal to the vertical pressure, and $a c$ will represent the pressure exerted in the direction of the center line of the connecting-rod.

To ascertain the pressure exerted on the crank-pin, it is a little more convenient to draw a horizontal line, $C D$, through the center of the crank-pin and parallel with $A B$. Then from C lay off $C e$, equal to the horizontal pressure, and draw the vertical line $e f$, then $f C$ will be the pressure exerted by the connecting-rod in the direction $a C$ of its center line. To determine the pressure that is exerted in the direction $g C$ at right angles to the crank $C O$, the force $f C$ may be resolved into two components, one acting in the direction $g C$ at right angles to the crank, and the other in the direction of $C O$ of its center line. If we extend $C O$ to h, and from f the end of $f C$, we draw $f g$ parallel to $O h$, the center line of the crank, and from the center C draw $C g$ at right angles to $C O$, and complete the parallelogram $f g C h$, then we have a parallelogram of which the diagonal represents the magnitude and direction of the force acting through the connecting-rod, and the sides are parallel to the direction into which we want to resolve this force. Therefore $g C$ represents the force exerted by $f C$ at right angles to the crank, and $h C$ that in the direction of its center line.

If the crank is in the position shown by the dotted lines at C', and the pressure of the connecting-rod is exerted on the crank-pin in the direction of the arrow r, then the rotative effect can be ascertained in a similar way to that already described—the horizontal line $C' e'$, equal to the horizontal pressure, is drawn through the center of the crank-pin, and the center line $b C'$ of the connecting-rod is extended to f'. A perpendicular $e' f'$ is then drawn from f' through e', and $C' f'$ is equal to the pressure of the connecting-rod on the crank-pin. A line $C' g'$ is drawn perpendicular to the center line $C' O$ of the crank, and through C' and f' lines $C' h'$ and $f' g'$ are drawn parallel to the crank, and from $f' f' h'$ is drawn parallel to $C' g'$. We then have the parallelogram $C' h' f' g'$, of which $C' g'$ or $h' f'$ represents the rotative effect.

QUESTION 529. *In what other way may we ascertain the pressure exerted at right angles to the crank, or the rotative effect?*

Answer. It can be shown that if the crank and connecting rod are drawn for any position of the piston, as in fig. 332, that if the line $e C$, representing the horizontal pressure exerted on the piston, is made equal to the length $O C$ of the crank, from center to center, and if the center line $a C$ of the connecting-rod is extended so as to intersect a vertical line $O K$ drawn through the center O of the axle, that the distance $O m$ will then represent the pressure exerted at right angles to the crank.* If, then, we MULTIPLY THE PRESSURE ON THE PISTON BY THE DISTANCE ($O m$ or $O n'$, fig. 332) FROM THE CENTER OF THE AXLE, AT WHICH THE CENTER LINE OF THE CONNECTING-ROD INTERSECTS A VERTICAL LINE DRAWN THROUGH THE CENTER OF THE AXLE, AND DIVIDE BY THE LENGTH OF THE CRANK, IT WILL GIVE THE ROTATIVE EFFECT. When the crank is back of the center of the axle, as at C', it is not necessary to extend the center line of the connecting-rod as it intersects the vertical line, as at n', without being extended.

QUESTION 530. *How may the rotative effect be most clearly shown for a whole revolution of the driving-wheel?*

Answer. To do this a circle, $L K$, fig. 333, is drawn to repre-

Fig. 332.

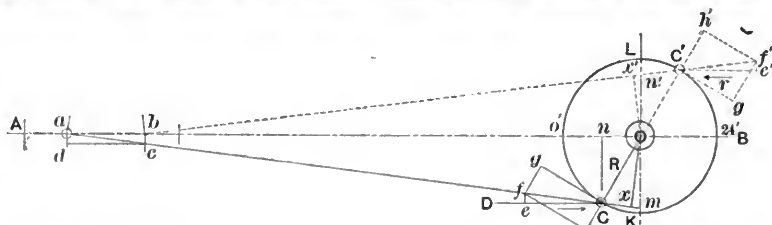
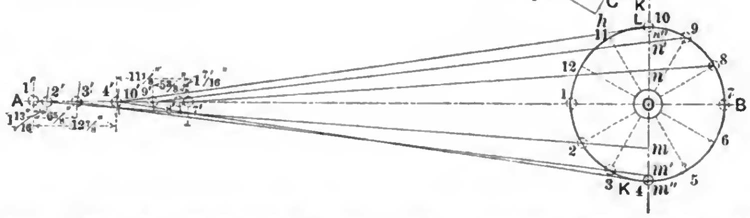


Fig. 333.



* It is not easy to prove this without the aid of mathematics. Those who know a little of geometry will be able to understand the following demonstration, those who do not must accept the conclusions without understanding the proof: In fig. 332, $e C$, which represents the pressure per square inch on the piston, has been made equal to the radius $C O$ of the crank, and as explained above $f C$ represents the pressure exerted through the connecting-rod on the crank. If the connecting-rod was infinitely long the leverage with which it would act on the crank would be equal to the vertical distance $C n$ of the center of the crank-pin, from the line $A B$, and the rotative effect would be equal to the pressure on the piston multiplied by $C n$. But owing to the angularity of the connecting-rod, the leverage through which it acts on the crank is equal to $O x$, a line drawn through the center O of the axle and perpendicular to $a C m$. So that the rotative effect is equal to the pressure $f C$ exerted through the connecting-rod, multiplied by $O x$. As the two triangles $C f e$ and $O x m$ are similar,

$$O x : O m :: C e : C f,$$

so that $O m \times C e = O x \times C f$.

As $C e$, which represents the horizontal pressure of the piston and reciprocating parts, has been made equal to $C O$ or R, the radius of the crank, we have

$$O m \times R = O x \times C f,$$

that is, the horizontal pressure of the piston and reciprocating parts multiplied by $O m$ is equal to the rotative effect. A similar demonstration will prove that $O n' \times R$ will be equal to the rotative effect when the crank-pin is in the position C'.

sent the path of the center of the crank-pin, and a horizontal center line *A B*, as described. Now divide the circle into 12 equal divisions—1, 2, 3, 4, etc. From the dead-points 1 and 7, with the length of the connecting rod as a radius, mark 1′ and 6′ on *A B*; these will represent the two ends of the piston's stroke. Now from 2 as a center, and with the length of the connecting-rod, intersect *A B* at 2′ with a short arc, and draw 2′ 2 *m*. Then 1′ 2′ will represent the distance that the piston has moved while the crank has turned from 1 to 2, or one-twelfth of its revolution. In a similar way 3 3′, 7 7′, 8 8′, 9 9′, can be laid down, which will give us the movement of the piston for successive twelfths of the stroke during the first and third quarters of a revolution. To avoid confusion in the diagram the position of the connecting-rod has not been laid out for the second and fourth quarters of the revolution, and also because the positions of the crank-pin and piston are the same during the first and fourth and the second and third quarters of the revolution.

horizontal lines below *C D* are supposed each to represent 10 lbs. pressure per square inch, as indicated by the figures on the left hand side of fig. 334, and the pressure which has been calculated can be laid off from 2‴ to *E*. Proceeding in the same way for the third position, 3 3′, of the crank, we find that the piston has moved 6⅝ in., as shown in fig. 333, and *O m′* is equal to 11⅓ in.

Therefore, $$\frac{140 \times 11\frac{1}{3}}{12} = 129.8.$$

This pressure is laid off from the line *C D* on the perpendicular 3‴ *F*. In the same way the rotative effect is calculated and laid down in fig. 334 for each of the successive positions, 4, 5, 6, 7, etc., of the crank, shown in fig. 333, and curves *C E F G H I J* and *J K L M N P D*, fig. 334, are drawn through the points laid down on the perpendicular lines. The vertical distance of these curves below *C D* then represents the rotative effect which is exerted at each point during a complete revolution of the driving-wheel.

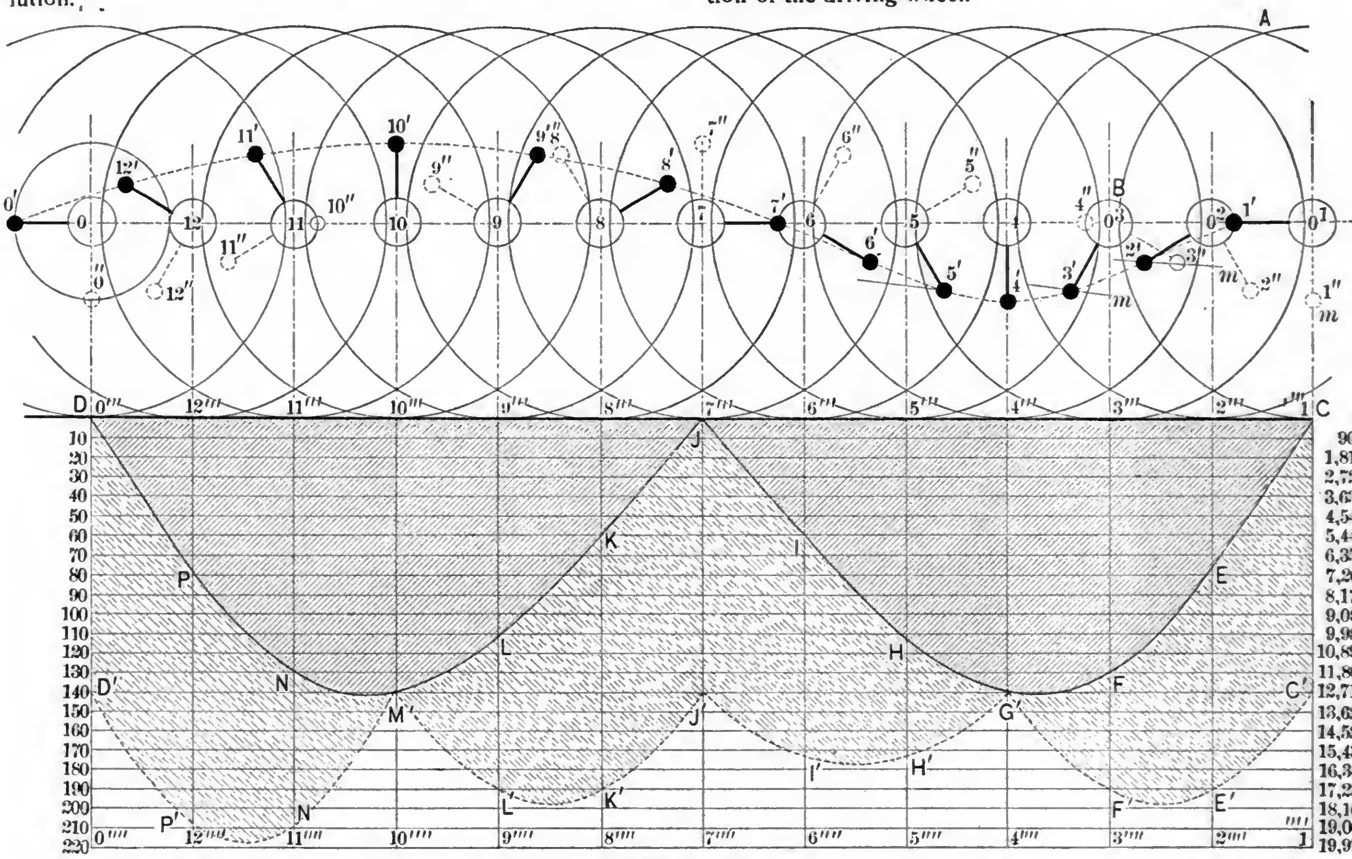


Fig. 334.

Next draw a horizontal line, *C D*, fig. 334, equal in length to the circumference of the driving-wheel, and subdivide this line into twelve equal divisions—1″ 2″ 3″ 4″ 5″ 6″, etc. From these points of division draw perpendiculars 1″ 1, 2″ 2, 3″ 3, etc. Draw the horizontal line 1 0 above *C D* so that 1 1″ and 0 0″ are equal to half the diameter of the wheel. Then from 1 as a center and with 1 1″ as a radius, describe a circle, *A B C*, to represent the driving-wheel, and from 1 lay off the crank-pin 1′ in the first position shown in fig. 333. As this is the dead-point the pressure of the piston exerts no rotative effect on the crank. From 2 lay off the crank-pin 2′ in the second position shown in fig. 333. As *C D* has been made equal in length to the circumference of the wheel, and it has been divided into twelve equal parts, 1‴ 2‴ is equal to one-twelfth of the circumference, so that the wheel *A B C* in turning one-twelfth of a revolution would roll from 1‴ to 2‴. From 2 as a center we then draw another circle to represent the wheel when it has turned one-twelfth of a turn and has rolled from 1 to 2. The crank is then in the position shown at 2′ in fig. 333, and the piston has moved $1\frac{3}{16}$ in. By drawing 2′ *m* to represent the connecting-rod, we find that *O m* is equal to 6¾ in. It will be supposed now that the engine is running at a speed of only four miles an hour, and that there is a uniform pressure of 140 lbs. on the piston, as shown by the diagram fig. 237. At this slow speed the power required to accelerate and retard the reciprocating parts is so little that it may be disregarded.

To get the rotative effect for the position of the crank shown at 2 2′, fig. 335, we must then multiply 140 × 6¾ = 945, and divide by 12, which gives 78.7 as the rotative effect *in pounds pressure per square inch of the piston*. The spaces between the

But while the pressure on the piston on one side of the locomotive is acting on its crank, there is a simultaneous action on the other crank which stands at right angles to the first one, and whose successive positions is shown by the dotted lines 1 1″, 2 2″ 3 3″, etc. The rotative effect acting on the wheels is therefore equal to that exerted on each of the cranks added together. To show this combined effect, then, we must lay off other curves from those already drawn. Thus, the opposite crank 1 1″ in the first position of the wheel stands at right angles to the center line 1 0, and *O m* is then equal to 12 in., so that we

have $$\frac{140 \times 12}{12} = 140.$$

Therefore 140 is laid down from 1‴ to *C′* on the vertical line 1‴ 1⁗. A similar calculation is made for the rotative effect of the crank 2 2″ in the second position, and it is laid off from *E* to *E′*. Proceeding in the same way for the other position of the crank, and laying off the distances *F F′*, *H H′*, etc., and drawing the curve *C′ E′ F′ G′ H′—D′* through the points thus laid down, we have a curve whose distance below the line *C D* represents the combined rotative effect exerted by the pressure in the two cylinders during a whole revolution.

QUESTION 531. *What peculiarity may be observed in the form of this curve?*

Answer. It will be seen that the rotative effect varies very much at different points of the revolution. It is greatest when the wheel is midway between the positions 11 and 12, when the two cranks are in front of the axle and stand at angles of 45° with horizontal or perpendicular lines. When the wheel is between the 2 and 3 and 8 and 9 positions, or when the cranks both

again stand at angles of 45° with a horizontal line, the rotative effect is equal, though somewhat less than it is when the cranks are both in front of the axle. Between the 5th and 6th positions of the wheel, when the cranks are both behind the axle and at angles of 45° to a horizontal line, the rotative effect is less than at any of the other high points.

QUESTION 532. *How may this peculiarity of the variation in the rotative effect be explained?*

Answer. It is due to the fact that when both cranks are in front of the axle the effect of the angularity of both connecting-rods is to increase the rotative effect. When one crank is in front and the other behind the axle, the one connecting-rod increases and the other diminishes the rotative effect, and when the two cranks are behind the axle, both rods diminish the rotative effect.

QUESTION 533. *At what points in a revolution is the least rotative effect exerted?*

Answer. When one of the two cranks is at a dead point, that is, in the 1st, 4th, 7th, and last positions shown in fig. 334. When the steam pressure is alike the rotative effect is equal in each of these positions of the cranks.

QUESTION 534. *When the rotative effect is represented in pounds pressure per square inch of piston, as in fig. 334, how can we know the actual rotative effect or the tractive force exerted at the circumference of the wheel?*

Answer. This can be done by simply measuring the vertical distances of the curve with a different scale. Thus, in fig. 334 the spaces between the horizontal lines below $C\ D$ have been supposed to represent 10 lbs. pressure on each square inch of the piston, as indicated by the figures on the left-hand side. If the piston is 17 in. in diameter its area would be very nearly 227 square inches. Ten pounds' pressure would therefore exert a total pressure of 2270 lbs. on the piston. If the wheel is 5 ft. in diameter and the stroke 2 ft., the pressure on the piston would be exerted with a leverage of 2 to 5, so that the actual tractive force would be

$$\frac{2270 \times 2}{5} = 908 \text{ lbs.}$$

for each ten pounds of pressure. If, then, we suppose the spaces between the horizontal lines each represent 908 lbs., as indicated by the figures on the right-hand side, we can measure the actual tractive force exerted at the circumference of the wheel.

QUESTION 535. *How can we lay off curves to represent the rotative effect when the pressure in the cylinder is not uniform during the stroke, and when the speed is so high that the acceleration and retardation of the reciprocating parts has an important influence on the action of the engine?*

Answer. To do this a diagram, fig. 335, similar to fig. 334, should be laid down. For each position of the crank we must ascertain the movement of the piston. Then construct a diagram like that represented by fig. 331, and from that take the net horizontal pressure exerted on the crank when the piston is in the position indicated. Thus, when the crank is in the second position represented in figs. 333 and 335, it has turned one-twelfth of a revolution, and the crank has moved $1\frac{3}{16}$ in. From the diagram fig. 331 we find that the pressure at $1\frac{3}{16}$ in. of the stroke measured above the line $E\ F$ is 65 lbs. As $O\ m$ is equal to $6\frac{3}{4}$ in., we have for the calculation,

$$\frac{65 \times 6\frac{3}{4}}{12} = 36.5.$$

We therefore lay off 36.5 from 2‴ to E. In the third position of the crank the piston has moved $6\frac{5}{8}$ in.; the pressure is then 90 lbs., and $O\ m$ is equal to $11\frac{1}{8}$, so that the rotative effect is equal to 83.4 lbs., which distance is laid off from 3‴ to F. Similar calculations are made for other positions of the crank, and the curves $C\ E\ F\ G—D$, and $C'\ E'\ F'\ G—D'$ are drawn in the manner described. The latter curve then represents the rotative effect when cutting off steam at one-third of the stroke and at a speed of 50 miles per hour.

QUESTION 536. *What is the effect of working steam expansively at high speeds?*

Answer. As already pointed out, the effect of cutting off steam early in the stroke, and the influence of the reciprocating parts, tends to equalize the rotative effect during the whole revolution of the wheel. This is shown by the curve $C'\ E'\ F'\ G—D'$, which shows that the rotative effect on the crank-pin does not vary nearly as much as the corresponding curve in fig. 334 shows that it does when the steam was not expanded and where the reciprocating parts moved slowly. There is also considerable irregularity in the curves in fig. 335, which is produced by the various and complicated causes which determine its form. The black areas at G and J represent the back pressure on the piston, shown also at F in fig. 331. The dotted line drawn through the centers of the crank-pin in figs. 334 and 335 show the path in which the pin moves during one revolution of the wheel.

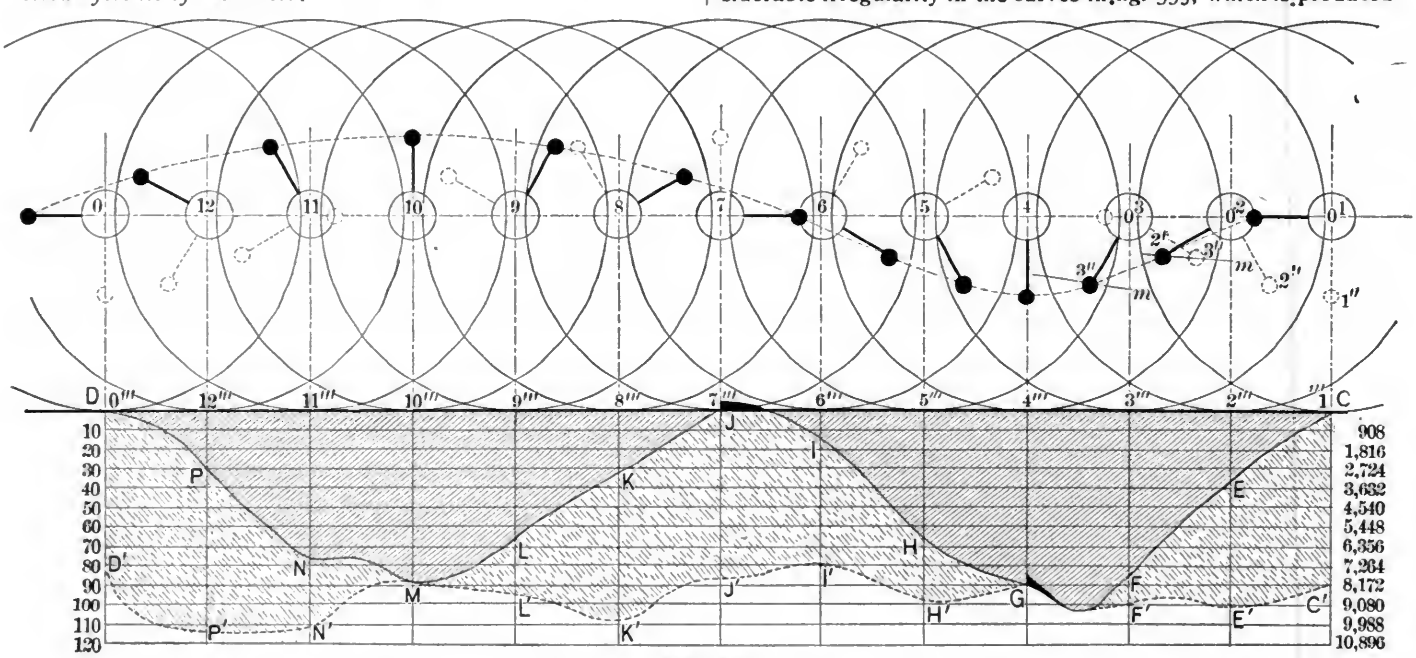


Fig. 335.

CHAPTER XX.

FRICTION AND LUBRICATION.

QUESTION 537. *What is meant by friction?*

Answer. Friction is the resistance between two bodies in contact which opposes the sliding of the one on the other. Thus, if a brick is placed on a board with a slight inclination, it will not slide because the friction between them, or the resistance opposed to motion, is greater than the force exerted by the weight of the brick to move it downward. If, however, the inclination of the board is increased sufficiently so that a larger proportion of the weight of the brick urges it downward, then the friction will be overcome, and it will slide. When the brake-blocks of a car are pressed against the wheels, they produce friction, which resists the revolving motion of the wheels, and if the resistance of this friction is greater than the propelling force, the car will ultimately stop; and when the weight of an engine is supported on the driving-wheels and they rest on the rails, the friction between them and the rails, as has already been pointed out, resists their slipping on each other, and thus enables a locomotive to exert tractive force. Friction also resists the turning of an axle on its journal, which is overcome by the tractive power of the locomotive.

QUESTION 538. *On what does the amount of friction depend?*

Answer. The amount of friction of two bodies in contact depends (1) UPON THE PRESSURE OF THE ONE ON THE OTHER, AND

SO FAR AS THE FRICTION OF THE PARTS OF RAILROAD MACHINERY IS CONCERNED MAY IN PRACTICE BE REGARDED AS INDEPENDENT OF THE AREA OF THE SURFACES IN CONTACT; (2) ON THE NATURE OF THE MATERIALS IN CONTACT; (3) ON THE NATURE OF THE SUBSTANCE, SUCH AS OIL OR OTHER LUBRICANT, WHICH IS INTERPOSED BETWEEN THEM; (4) ON THE SPEED; (5) ON THE TEMPERATURE. Thus, a brick will slide down an inclined board as easily if it is laid on its broadest side as it will if placed edgewise; and if a cast iron plate, say 10 inches square, is planed and scraped, so as to be as nearly a perfect plane surface as it is possible to make it, it will, if loaded with, say, a hundred pounds' weight, slide on a similar true surface as easily as another plate with half as much area and loaded with the same weight. A shaft resting against a long bearing will require no more power to turn it than would be needed if the bearing was short.*

QUESTION 539. *What is meant by the "co efficient of friction?"*

Answer. It is the proportion which the resistance to sliding motion bears to the force pressing the surfaces together. Thus, a smooth, clean, and dry cast iron plate loaded with 100 pounds will require a force of about 15 pounds, or fifteen one-hundredths of the weight or pressure of the plates, to slide them on each other. The *co-efficient of friction* is therefore said to be 0.15, and with any other weight or pressure on the plates we could determine the force required to slide them on each other by multiplying the pressure by the co-efficient of friction. Thus, if the plates were loaded with 250 pounds, the force required to slide the one on the other would be equal to $250 \times .15 = 37.5$ pounds. The co-efficient of friction, however, varies for different materials. Thus, while it is 0.15 between two pieces of smooth, clean, and dry cast iron, the co-efficient of a piece of brass on cast iron, under similar conditions, is 0.22, and of two pieces of wood about 0.4.

QUESTION 540. *What is the effect of introducing some unguent or lubricating material, such as oil, between the surfaces in contact?*

Answer. The co-efficient of friction is very much reduced thereby. Thus, the co-efficient of the cast iron plates, if their surfaces are greased with tallow, is 0.1; if lubricated with lard 0.07, with olive oil 0.064, and with lard and plumbago 0.055, thus showing that the amount of friction depends very much upon the nature of the lubricant which is used, as well as on that of the materials in contact.

QUESTION 541. *What effect on the amount of friction has the manner of applying the lubricating material to the surfaces in contact?*

Answer. The more perfect the lubrication the less will be the co-efficient of friction. It has, for example, been found by experiments made with cast iron shafts turning on bearings of the same material that when the lubricating material was applied so that the surfaces were only "unctuous," that is, slightly greasy, the co-efficient of friction was very little less than when they were dry, that is, when there was no lubricating substance between them, and that when they were greased "from time to time" the co-efficient was reduced to 0.07 and 0.08; but when they were continually oiled it averaged 0.05, and sometimes fell as low as 0.025, showing that with the best lubrication the friction was only one-sixth what it was when the surfaces were only "unctuous." Between these two limits there is every degree of frictional resistance, according to the condition of lubrication. This shows how important it is that the oiling fixtures should be kept in the most perfect condition and the utmost care be exercised in keeping every part of a locomotive thoroughly lubricated.

QUESTION 542. *What effect does the pressure per square inch of the surfaces in contact have upon the lubrication?*

Answer. The tendency is, when this pressure becomes excessive, to press out the lubricant which is between the two surfaces, and ordinary experience proves that the greater the weight or the force per square inch with which two bodies are pressed together, the greater is the difficulty of keeping them perfectly lubricated.

Thus it is easier to keep the journals of a car well lubricated when it is empty than when it is heavily loaded, and the guide-bars of a locomotive are more liable to be abraded when the engine is pulling a heavy load than with a light one.

QUESTION 543. *What effect has the velocity of the surfaces in contact on the friction and lubrication?*

Answer. With the surfaces in the same condition, the friction is nearly independent of the velocity of motion of the surfaces against each other, but perfect lubrication becomes more difficult as the velocity increases, so that an increase of velocity will often increase indirectly the amount of friction. Thus, taking our previous illustrations, it is more difficult to keep the journals of a car or engine well lubricated when running fast than when running slow, and the same thing is true of the guide-bars.

QUESTION 544. *What considerations should govern the proportions of frictional bearings for locomotives and other machines?*

Answer. The dimensions to be given them should not be determined from a consideration solely of their resistance to rupture,* but they should be made so large that the pressure they must bear will be distributed over so much surface that the proportion borne by each square inch will be comparatively small, thus making good lubrication much less difficult, and consequently reducing the co-efficient of friction.

QUESTION 545. *Is not the amount of energy required to overcome the friction on a journal of large diameter greater than would be required if the journal was smaller?*

Answer. If the co-efficient of friction in the two cases is the same, undoubtedly the large journal will require the greatest expenditure of energy to turn it, because its periphery moves further than that of the small one; but the advantage attributed to large journals is that they can be lubricated more perfectly, because their surfaces being larger the pressure is not so great per square inch, and thus the gain from the reduction of the co-efficient of friction is greater than the loss attributable to the increase of the diameter of the journal. Thus, if a car journal is $3\frac{1}{4}$ in. in diameter $\times$ $5\frac{1}{2}$ in. long, the available surface exposed to friction is equal to that of a longitudinal section of the journal, or $3\frac{1}{4} \times 5\frac{1}{2} = 17.875$ square inches.† Supposing now that the journal is loaded with 5,000 pounds, and the average co-efficient of friction is 0.085. In one revolution of the wheel the journal will move 0.85 of a foot, and therefore $5,000 \times .085 = 361\frac{1}{4}$ foot-pounds of work. If, now, the journal is made, as has been proposed, $3\frac{3}{4} \times 7$ in., then its effective surface will be equal to $26\frac{1}{4}$ square inches, but the journal will move 0.98 of a foot in one revolution. If, however, the lubrication is improved by the increased area of the journal so that the co-efficient of friction is reduced from 0.085 to 0.07, then the energy consumed in one revolution will be equal to $5,000 \times 0.07 \times .98 = 343$ foot-pounds, or less than was consumed with the small journals. The co-efficient of friction is assumed, and could only be determined by experiment, but the assumption shows how the resistance of the large journals may be less than that of the small ones. Of course it would be better to give the increased bearing surface by adding to the length of the journal, but nearly all locomotives and car journals must be increased in diameter as well as in length when they are enlarged, in order to have the requisite strength to carry the loads they must bear.

QUESTION 546. *Is the law that* FRICTION IS IN PROPORTION TO THE PRESSURE ON EACH OTHER BY THE SURFACES OF CONTACT *true under all circumstances?*

Answer. No; there is a limit to the exactness of the above law, when the pressure becomes so intense as to crush or grind the parts of the bodies at and near their surfaces of contact. At and beyond that limit the friction increases more rapidly than the pressure;‡ and the friction then becomes very irregular.

QUESTION 547. *In what cases is the limit referred to probably reached?*

Answer. Probably in some locomotives the pressure of the driving-wheels on the rails is sufficient to partly crush the latter.

QUESTION 548. *What effect has the nature of the materials in contact on the friction?*

Answer. The amount of friction and also the lubrication is very much influenced by the nature of the bearing surface and also by the material used as a lubricant. Some metals, such as brass and other alloys, are much less liable to abrasion, and seem to retain lubricants on their surfaces better than other metals, and are therefore much used for journal and other bearings. Some substances, especially oils, are good lubricants, while other materials of apparently similar nature are not. The reason why these materials possess these properties while others are without them is not known, and the value of any material as a lubricant, or the degree to which another will resist friction without abrasion, can only be tested by experiment.

CHAPTER XXI.

COMBUSTION.

QUESTION 549. *What is meant by combustion?*

Answer. By combustion is meant the phenomenon ordinarily called burning, as when a piece of wood or coal or a candle is burned. In reality combustion is a union of one of the "*chem-*

* Ordinarily somewhat less power is required to turn it if the bearing is long than if it is short, the reasons for which will be explained hereafter.

* Morin's Mechanics.

† The reason for this is that the effective surface of the journal which resists the pressure of the bearing, is equivalent only to the horizontal area just as the surface which resists the pressure inside of a boiler is equivalent to the diameter multiplied by its length, as was explained in answer to Question 191.

‡ Rankine.

ical elements," oxygen, of which the atmosphere is composed, with the elements which constitute the fuel.

QUESTION 550. *What is meant by the term "chemical element?"*

Answer. The science of chemistry has demonstrated that nearly all substances by which we are surrounded are composed of certain other substances, which latter, as far as is now known, are not compounds, and are therefore called *elementary substances, or chemical elements.* Thus, the air by which we are surrounded is composed of two gases, called nitrogen and oxygen ; water is composed of hydrogen and oxygen, and coal chiefly of carbon and hydrogen. There are now over sixty of these elementary substances known. From no one of them have chemists been able to extract any material excepting the substance itself. These elementary substances will combine with others so as to form what is apparently a new material, but on weighing it it will be found that the weight of the new material is greater than the original elementary substance, showing that something was added to it which effected the change.*

QUESTION 551. *To what fact is this combination or combustion of elementary substances due?*

Answer. It is owing to the fact—the exact reason for which is, perhaps, not yet understood fully—that the atoms of the elementary substances of which fuel is composed, that is, hydrogen and carbon, and the atoms of oxygen, which forms part of the atmosphere by which we are surrounded, attract each other with great energy when they are excited into activity by the application of heat.

QUESTION 552. *What phenomenon always attends chemical combination of substances?*

Answer. Such combination always gives out heat, whereas their separation absorbs heat. It has further been proved by actual experiment that the amount of heat liberated by the chemical union of the same quantity or number of atoms of two or more substances is always the same, and that when, by any cause, the atoms thus joined are separated, exactly the same amount of heat is absorbed.†

QUESTION 553. *In what proportions do the elementary substances combine with each other?*

Answer. It is a law of chemistry that each of the elementary substances combines with the others in certain definite proportions only. These proportions vary for the different elements, and have been determined with great accuracy by chemists. Thus, eight parts by weight of oxygen will combine with nitrogen and form atmospheric air, or the same proportion of oxygen will combine with hydrogen and form water, or with carbon and form carbonic acid, which is the deadly gas which accumulates at the bottom of wells.

Now oxygen always combines with other substances in the proportion of eight parts by weight, or by *some simple multiple of* eight, that is, $8 \times 2 = 16$ parts, or $8 \times 3 = 24$ parts, etc. Each of the other elementary substances also has a certain fixed proportion in which it combines with others, and this proportion, which is usually given by weight, is represented by a number called its *chemical equivalent.* Thus 8 is the chemical equivalent of oxygen. Carbon combines with other elements in proportions of 6 and nitrogen in proportions of 14, so that 6 and 14 are the chemical equivalents of carbon and nitrogen. Now 8 parts by weight of oxygen can be made to combine with 14 parts of nitrogen, or $8 \times 2 = 16$ parts of oxygen will combine with 14 of nitrogen, but it is impossible to make, say 12 parts of oxygen combine with 14 parts of nitrogen. We can combine $14 \times 2 = 28$ parts of nitrogen with 8 parts of oxygen, but no chemical process can make say 10 or 20 parts of nitrogen combine with 8 parts of oxygen. If 20 parts of nitrogen are mixed with 8 parts of oxygen, then the latter will combine with 14 parts of the former, but 6 parts of nitrogen will be left, and chemical combination will then cease.

The following table will give the chemical equivalents of the principal elements which enter into the process of combustion of the fuel used in locomotives :

	Chemical equivalent by weight.
Oxygen	8
Nitrogen	14
Hydrogen	1
Carbon	6
Sulphur	16

QUESTION 554. *What effect do the proportions in which elements are combined have upon the substances which are produced by the combination?*

Answer. A change in the proportions in which the elements are combined usually alters the entire nature of the substance, so far at least as it affects our senses. For instance, oxygen unites chemically with nitrogen in different proportions, forming five distinct substances, each essentially different from the others, thus :

14 parts of Nitrogen with	8	of Oxygen	forms	Nitrous Oxide.
14 " " " "	16	"	"	Nitric Oxide.
14 " " " "	24	"	"	Hyponitrous Acid.
14 " " " "	32	"	"	Nitrous Acid.
14 " " " "	40	"	"	Nitric Acid.

We here find the elements of the air we breathe, by a mere change in the *proportions* in which they are united, forming distinct substances, which differ from each other as much as *laughing gas* (nitrous oxide) does from that most destructive agent *nitric acid*, commonly called *aqua-fortis.**

QUESTION 555. *What occurs when a fresh supply of bituminous coal is thrown on a bright fire in the fire-box of a locomotive?*

Answer. The fresh coal is first heated by the fire, and if a sufficient quantity is thrown in to prevent the immediate formation of flame,† a volume of gas or vapor, usually of a dark yellow or brown color, is given off. The quantity evolved will be greatest when the coal is very small. This gas or vapor is commonly called smoke, but it does not deposit soot and in reality is not true smoke. If a sheet of white paper be held over the vapor as it escapes from the coal and there is no flame, the sheet will become slowly coated with a sticky matter of brown color difficult to remove, and having a strong tarry or sulphurous smell ; whereas if a sheet of paper is held over smoke it will quickly be covered with black soot. The color and smell left on the paper in the first case are due to the tarry matter, sulphur, and other ingredients in the gas. Deprived of the coloring matters, the vapor is a chemical mixture of 2 parts of hydrogen and 6 parts of carbon, and is called carburetted hydrogen, and is nearly the same as the colorless gas by which our houses are lighted.‡ A similar gas is generated at the wick of a burning candle or lamp and is consumed in the flame. Before the gas is expelled from the fresh coal the latter must be heated to a temperature of about 1,200 degrees, so that if 100 pounds at a temperature of 50 degrees is put on the fire 23,000 units of heat will be absorbed to heat the coal.§ Nor is this all, as has been explained in answer to Question 38, when any substance is vaporized a certain amount of heat apparently disappears, which has been called the *heat of evaporation* or *of gasification.* Average bituminous coal contains about 80 per cent. of carbon, 5 per cent. of hydrogen, and 15 per cent. of other substances usually regarded as impurities. When the coal is heated up to about 1,200 degrees, the 5 per cent. of hydrogen unites with three times its weight of carbon, and thus 20 per cent. of the coal is converted into the gas described. In this process a large amount of heat is absorbed or becomes latent, as it does when water or any other substance is converted into vapor. It will therefore be seen that the first effect of putting fresh coal on the fire *is to cool the fire.* This fact has an important bearing on the question of combustion and will be referred to hereafter.

(TO BE CONTINUED.)

* "The New Chemistry," by J. P. Cooke, Jr.

† *Ibid.*

* Combustion of Coal and the Prevention of Smoke, by C. Wye Williams.

† Usually if more than two or three shovels full are thrown in there will be no immediate formation of flame.

‡ A Treatise on Steam Boilers, by Robert Wilson.

§ The quantity of heat required to heat coal is only about one-fifth that needed to heat the same weight of water to the same temperature.

Manufactures.

Bridges.

WORK has been begun on the new bridge over the Mississippi at Memphis, Tenn. This bridge will have a cantilever channel span of 770 ft., the longest yet built in the world, and two others of 620 ft. each. It is to be 34 ft. wide and 75 ft. above high water, with accommodation for a double-track railroad and a roadway for vehicles. The west approach will have an iron trestle 5,200 ft. long and a 1,800-ft. embankment ; the east approach will have a 1,000-ft. trestle. The estimated cost is $2,200,000.

THE Philadelphia Bridge Works of Cofrode & Saylor at Pottstown, Pa., are furnishing all the iron beams, roof trusses and other iron work for the new passenger station of the New Jersey Central Railroad in Jersey City.

THE National Paint Works, Williamsport, Pa., have fur-

nished paint for the Poughkeepsie Bridge, the new bridge over the Ohio at Cincinnati, and several other large structures.

THE Berlin Bridge Company, East Berlin, Conn., has a number of orders on hand for bridges and roof work.

THE new bridge over the Missouri River, between Omaha and Council Bluffs, cost $800,000, and is the property of a local company. It is, with the approaches, 4,600 ft. in length and has a 25-ft. roadway with 8-ft. sidewalk. The roadway has a single track for the motor car line. Mr. Frank D. Moore is Chief Engineer of the Company. Hopkins & Scully, of St. Louis, were the contractors for the pier and superstruction. The Edgmoor Iron Works of Wilmington, Del., superintended and supplied the iron work.

Locomotives.

THE Grant Locomotive Works, Paterson, N. J., are building 15 locomotives for the New York, Lake Erie & Western Railroad.

THE Rogers Locomotive Works, Paterson, N. J., have a large order for locomotives for the Chicago, Rock Island & Pacific Railroad.

THE New Jersey Central Railroad is about to add to its motive power 30 consolidation engines with the Wootten fire-box.

IN the shops of H. K. Porter & Company, Pittsburgh, two locomotives for a Japanese railroad are in progress. This firm has already sent several engines to that country.

Electric Notes.

BY an agreement made between the Westinghouse Electric Company, of Pittsburgh, and the Consolidated Electric Company, of New York, the former is placed in control of the latter company. The property of the company absorbed consists of a large manufactory on West Twenty-third Street, New York, and another in Pittsburgh. The use is given to the Westinghouse Company of all the Sawyer-Mann patents and entire capital stock of the Sawyer-Mann Electric Company.

THE Electric Automatic Transit Company, controlling the patents for sending automatic cars or cartridges great distances at enormous speed, have nearly completed their plant and two miles of track at Laurel, Md. The building is 30 by 40 ft., and contains a boiler-room, engine and dynamo-room, and an office. Already the twin boilers of 125 H.P., with a 56-ft. stack, are in position, and the 130 H.P. Ball automatic cut-off engine is ready to run. It has a speed of 300 revolutions per minute. The dynamo for generating electricity is expected from the Sprague Works in New York in about two weeks, and an iron car 30 in. deep, 24 wide and 18 ft. long will be turned out within five days. The machinery for the car is to come from the Sprague Works. The electric connections will require about a week to make. Various experiments will be made to get the best results possible by Mr. David G. Weems, the inventor, and Messrs. George H. Tegmeyer and B. J. Dashiell, the engineers. The car, which is pointed at the prow, runs on wheels 28 in. in diameter on tracks 28 in. apart. The electricity comes from a central upper rail. The brakes will be worked by electricity. It is claimed that from where the plant now stands cars could be run from Baltimore to Washington and return loaded with mails and unattended by any one.

Manufacturing Notes.

A LARGE patented screw-power testing machine of 100,000 tons capacity, with all the recent improvements, has been erected at the United States Navy Yard, Boston. It was built by Messrs. Riehle Brothers, Philadelphia, the same firm who supplied the testing machine to the United States Navy Yard at Mare Island, Cal., also at the Naval Academy at Annapolis, and the United States Military Academy at West Point, and have furnished in all nearly 30 of their testing machines to the United States Government alone. The machine at the Boston Navy Yard was critically examined and reported upon by a special board of naval engineers, appointed by G. W. Melville, Chief of the Bureau of Steam Engineering, the report being very favorable. Another testing machine will be shipped shortly to the Thompson Electric Welding Company, of Lynn, Mass.; one to the famous ship-building firm of Hereshoff & Company, Bristol, R. I.; and one to the Dennis Long Company, of Louisville, Ky.

THE Southwark Foundry & Machine Company, Philadelphia, intends making extensive improvements to the now very large plant. Two traveling cranes of 30 and 50 tons capacity will be put in the shops. There are at present under way four centrifugal pumps, with their engines and boilers, two of which are for the Norfolk Navy Yard dry dock, and two for that at the Brooklyn Navy Yard. Each of these pumps is capable of discharging 40,000 gallons of water per minute, and are similar to those made for the Mare Island Navy Yard dock at California. They are also making the pumps for the dry dock at Newburyport.

THE Cobb Vulcanite Wire Company, Wilmington, Del., is putting in new machinery which will more than double its plant, making the works the largest manufactory of insulated wire in this country. The works are now running to their full capacity, but are still behind with their orders.

THE Tanite Company, Stroudsburg, Pa., is continually devising and introducing new uses for emery. Among the latest are a solid emery oil-stone, which is a stone or block of convenient size for sharpening tools, and is similar in quality to the Tanite emery wheels. Two grades of these stones are made; one for putting on a rough edge, and one for a cutting edge on fine tools. The rough edge stone will do the same work that a grindstone will. Another, intended for household use, is a knife-sharpener, which personal experience has shown to be of excellent quality.

THE Ranken & Fritsch Foundry & Machine Company, St. Louis, successors to the Smith, Beggs & Ranken Machine Company, are proceeding rapidly with the improvements at their extensive establishment. The work of adding another story to the erecting shop will be completed shortly, when a large amount of new machinery, including a planer much larger than any at present in St. Louis, a new boring mill, and other new and improved tools, will be put in.

THE Westinghouse Air-Brake Company has made a contract with the American Brake Company, of St. Louis, under which the Westinghouse obtains control of the American Company's patents and guarantees the latter a certain interest on its capital stock. The contract has been ratified, and the Westinghouse Company has taken full possession.

Marine Engineering.

THE new steamship *Corona*, built by Messrs. Neafie & Levy, of Philadelphia, for the Oregon Improvement Company, is about completed. She is built entirely of steel, and is 235 ft. long, 36 ft. beam and 23½ ft. depth of hold. She is schooner-rigged, the masts entirely of steel. She has accommodation for 125 cabin and 50 steerage passengers, while no expense has been spared for their comfort. The joiner work was done by Messrs. Hoffmire & Son, of New York. The machinery consists of the vertical triple expansion, surface condensing engines, expected to develop 1,350 I.H.P. with a steam pressure of 150 lbs. and making 150 revolutions. The cylinders are 20, 31 and 51 in. diameters by 36 in. stroke of pistons. Piston slide valves on all cylinders are worked by eccentrics in the usual manner. The air and circulating pumps are driven off the main engine by side levers. One side of the engine is open, formed of strong wrought-iron columns, thus making all working parts very accessible and convenient for lining up. The boilers are of steel, four in number, 10 ft. in diameter by 11 ft. long, each having two corrugated furnaces, manufactured by the Continental Iron Works, of Brooklyn, N. Y. The vessel is steered by Williamson's patent steering gear, and has also four hoisting engines of their make for discharging cargoes.

Two steam capstans and a steam windlass of the American Ship Windlass Company's make have also been put on, and are of their latest and most approved pattern. The rigging, which is entirely of steel, was done by Charles Thomas & Sons, of Philadelphia.

THE Harlan & Hollingsworth Company, Wilmington, Del., has made a contract to build a new ferry-boat 158 ft. long, 55 ft. over all, and 12 ft. deep for the Camden-Philadelphia ferry. She will have a beam engine with cylinder 42 in. diameter and 10 ft. stroke. The same company is to build a yacht 112 ft. long, 18 ft. beam and 12½ ft. deep for Dr. W. Seward Webb. The yacht will be built of the best open-hearth steel throughout, both in plating and beams and angles, and will be furnished with motive power by a triple-expansion compound engine of latest design, and a patent upright tubular boiler, for a working pressure of 160 lbs. of steam.

THE new steel twin-screw ferry-boat *Bergen* recently launched at Newburgh, N. Y., for the ferry between New York and

Hoboken, is the first large boat of this kind built in this country, except one on the Detroit River.

The *Bergen* is 200 ft. long, 37 ft. wide over the plating, 55 ft. wide over all, with a draft of 8 ft. 9 in., and a depth of 14 ft. Her cabin will be a clear interior 125 ft. long by 15 ft. wide.

The propeller shaft extends the whole length of the boat, carrying on each end a cast-steel propeller wheel 8 ft. diameter and 9 ft. 3 in. pitch. The engine is of the triple-expansion type, with cylinders 18½, 27, and 42 in. diameter and 24-in stroke. The working pressure will be 160 lbs.

THE Cleveland Ship-Building Company recently launched the steel steam barge *Transfer*, built for the Michigan Central Railway Company to be used as a railroad ferry-boat at Detroit. Her length over all is 280 ft., 45 ft. 6 in. beam, 17 ft. 3 in. hold, and 75 ft. from outside to outside of guards. It is estimated that she could break through ice 3 ft. thick without injury, and could be sailed through ice 1 ft. in thickness at a speed of seven miles per hour. Her screw wheel is 9 ft. in diameter, and her side wheels are shod with heavy steel facings to assist in breaking ice. The power which is to push her through water or ice of above thickness is in four steel boilers 11 ft. 6 in. diameter, 16 ft. long, or 4½ ft. longer than the longest ordinary boilers on the Lakes. These boilers have two domes 20 ft. long and 48 in. in diameter, and one dome 10 ft. long and 6 ft. in diameter. These boilers will furnish steam for six cylinders: two 28 × 28 in. on each side for the side-wheel engines, and two cylinders 28 × 36 in. for stern-wheel engine, each with separate condensers.

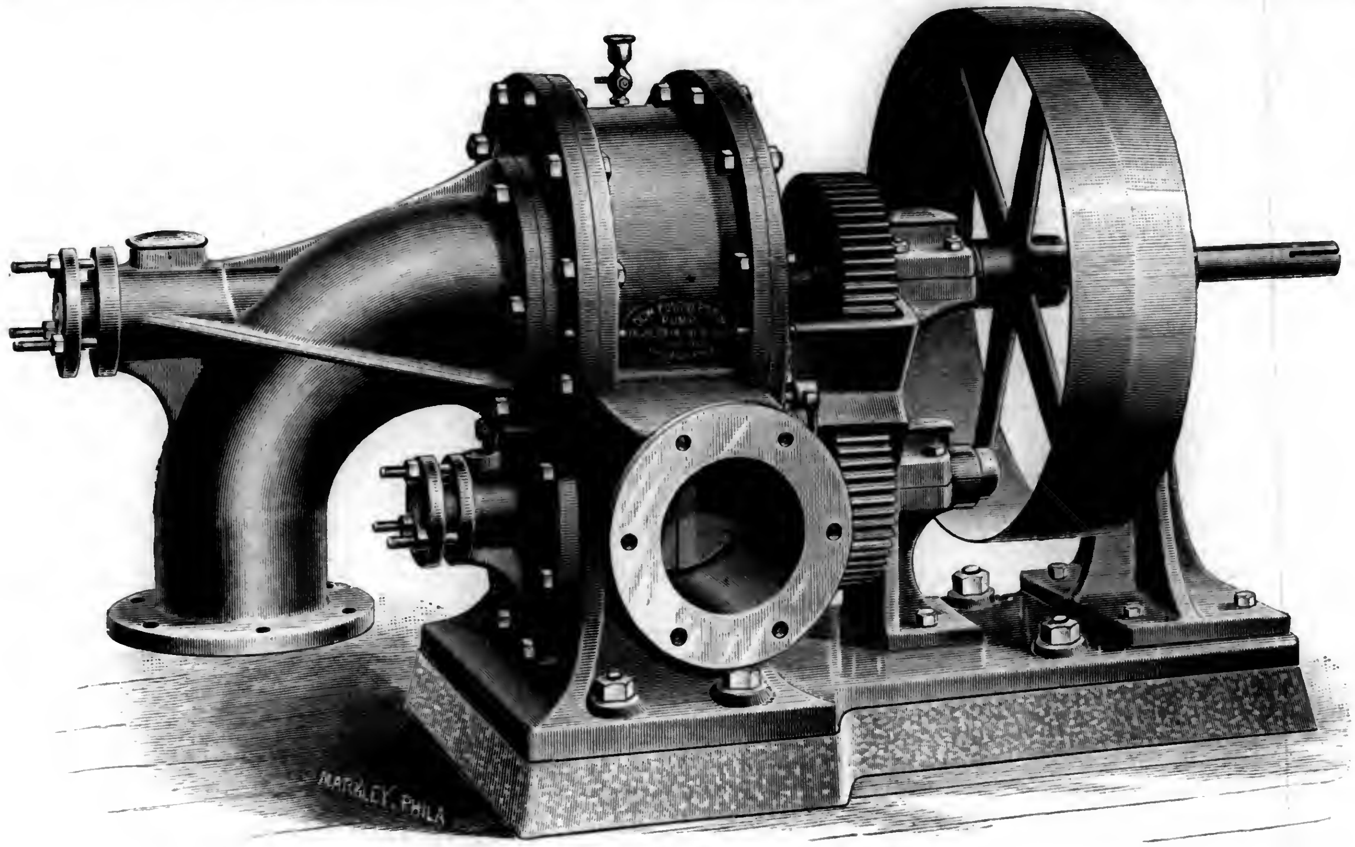
The Dow Positive Piston Pump.

THE accompanying illustrations show the Dow "positive piston" pump, fig. 1 being a perspective view and fig. 2 a section.

This pump is of an entirely new type, the builders of which claim that it fully and efficiently realizes the long-sought-for perfect action of a piston (or plunger) moving in one direction only, and that it overcomes many difficulties encountered in all other pumps; among them the resistance produced in reciprocating plunger pumps through necessity for reversing the motion of the current within the chamber (a resistance increased with the speed), also that caused by subdivision in passing small valve openings, and the impact of the fluid against the valves themselves, which offer a direct impediment to the flow.

This pump avoids loss of power and excess of wear and tear, as no work is done upon the fluid within it except to move it directly forward in a freely open channel. These and other advantages herein described result in an unusually large capacity in proportion to the power used, and permit a high rate of speed without concussion or disagreeable vibration. The action is as positive under a low rate of speed, and at any speed remarkably quiet.

The "Positive Piston Pump" has two annular chambers side by side, surrounding an internal cylinder (and separated by the central partition); in each of these chambers moves a single piston, with its strengthening wings, making the pump duplex in its action. The pistons are so placed that a perfect balance of all the parts, and of the fluid moving through them, is maintained. The suction is central, passing through the internal cylinder, which is attached to and revolves with the main shaft. This cylinder supports the pistons, and has openings behind them, between their strengthening wings; screw propeller-shaped suction blades within the cylinder lead to these openings through which the fluid passes, drawn by action of the pistons, which, in their travel, cause a suction in the same manner as with a reciprocating plunger, the ends of the annular chambers



THE DOW POSITIVE PISTON PUMP.

being completely closed by the abutment cylinder, which is in close contact and revolves in equal time with the piston cylinder, the closing being aided, when necessary for very high heads or use as a fire-pump, by an efficient packing. The movement of the fluid is aided, as it flows through the internal cylinder from the center outward to the annular chambers, by the suction blades and by centrifugal force. Through an opening in the abutment cylinder the piston finds passage, but immediately after it the closing is again made perfect.

While the suction is taking place behind the pistons, the contents of the chambers before them are being continually forced through the discharge opening, which is in a direct tangent to the action of the pistons, and presents a free course to the current, which is equal in volume to the displacement. When high suction is to be obtained without priming, two hinged valves are provided in the discharge opening, one for each chamber, and are dropped upon their seats to control the great elasticity of air; the suction is then readily obtained. Upon establishing the current, these valves are raised and held completely out of it, they being no longer of use. No frictional contact of the moving parts with each other or with the case has been found necessary to secure and maintain the full current. With very high lifts, however, an efficient packing is used. The wear is almost entirely confined to outside journals, and therefore readily controlled.

One of the important applications of this pump has been to run it with a belt or otherwise at comparatively low speed, for

ordinary use, and with a coupling to readily connect with a high-speed shaft for extraordinary supply or use as a fire-pump. As the pump runs equally well at high or low speed, the discharge can be regulated at will.

This pump, it is claimed, is the most economical machine yet discovered for lifting large or small volumes of water. It has been thoroughly tested in service.

The same principle has been applied to a blower and a pressure blower, with excellent results.

The Kensington Engine Works, Limited, Beach and Vienna streets, Philadelphia, are the sole licensees and manufacturers, under the American and foreign patents of Josiah Dow.

Cars.

THE Union Switch & Signal Company, Swissvale, Pa., has arranged for the exclusive right to manufacture and sell a new form of car buffer invented by Mr. George Westinghouse, Jr., which, it is believed, will meet a heretofore unfilled want—namely, a device offering resistance to the inward movement of the draw-bar sufficient to absorb in itself the momentum of the load in ordinary working in such a way that the shock and consequent injury to the car, heretofore considered inevitable, will be obviated. The device in question consists of a cast-iron box containing a number of thin plates secured to it, and a like number of thin plates placed between those in the box and attached to movable pieces against which the draw-bar presses. When the draw-bar is pressed inwardly these thin plates are, by a simple wedge device, clamped or squeezed together so as to offer an immense frictional resistance to further inward movement, which together with the resistance of the main springs (the same as heretofore used), absorbs such an amount of momentum that it is possible to run one car into another at a speed of eight or ten miles an hour without fully exhausting the frictional resistance and compression of the springs. Not only do the friction plates of the buffer offer an immense resistance, but the reaction of the main springs is prevented, thus assisting materially to decrease the risk of breaking trains in two. The apparatus is simple in construction, and is applicable to any form of draw-bar, but will be particularly valuable in connection with the Janney type of coupling, which does not at all times admit of the action of the dead-blocks. The apparatus has been designed with reference to securing uniformity in draw-gear, and is applicable to all classes of cars, freight and passenger, and its peculiar construction admits of a new method of attaching draw-gear, which will give all the practical effect of a continuous draw-bar, if desired.

THE works and warehouse of Joel H. Woodman & Company, New York, have recently been altered and improved, to meet the requirements of their large business in car-seats, head-linings and general veneer work. This firm makes a specialty of railroad and car work, carrying a great variety of designs. A branch house in London is also doing an excellent business.

THE Pennsylvania Company's shops at Fort Wayne, Ind., have just completed 200 Union Line box cars of 60,000 lbs. capacity, and are now at work on an order of 75 stock cars which are to be equipped with air brakes and Janney couplers. Following this order is another of 100 box cars. All these cars are equipped with a standard draft-rigging, and so arranged that at any time, should it be desired, the Janney coupler may be substituted for the wrought-iron draw-bar now in use, without changing the draft-rigging.

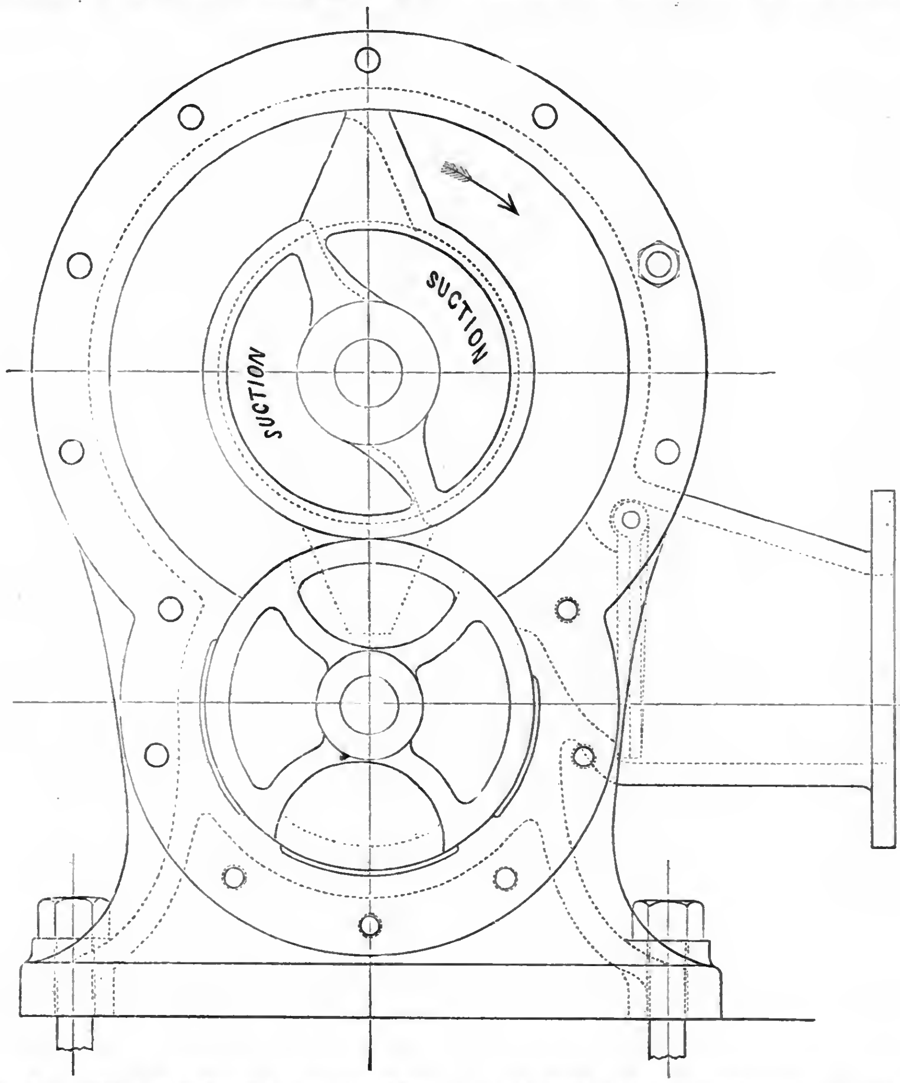


Fig. 2.

THE Treat Car-Wheel Works, Hannibal, Mo., are building a branch foundry at East Chicago, which will have a capacity of 400 wheels per day.

THE Milton Car Works, Milton, Pa., have an order for 500 box and 500 coal cars for the New Jersey Central Railroad.

THE Erie Car Works, Erie, Pa., are busy on several large orders for freight cars.

THE Laconia Car Company, Laconia, N. H., is building 200 box cars for the New York, Lake Erie & Western Railroad, fitted with the Eastman car-heater. They will be used to carry fruit and similar freight.

THE car shops of McKee, Fuller & Company, Catasauqua, Pa., are building 2,000 coal cars for the Lehigh Valley Railroad.

THE shops of the United States Rolling Stock Company at

Anniston, Ala., are building freight cars for the Alabama Great Southern and the Georgia Pacific roads.

THE Ohio Falls Car Works, Jeffersonville, Ind., are building a number of freight cars for the East Tennessee, Virginia & Georgia Railroad.

IT is stated with authority that an organization, to be known as the Union Palace Car Company, has been formed by parties holding a controlling interest in the Mann Boudoir and the Woodruff Sleeping-Car companies. A large interest in these companies had been acquired by the Jackson & Sharp Company and the Harlan & Hollingsworth Company, of Wilmington, Del., in whose workshops many of the cars for the Mann and Woodruff companies have been built and stock largely taken in payment therefor. It is stated that the new company has been organized with a capital of $3,000,000. Contracts have been placed by the new company with the Jackson & Sharp and the Harlan & Hollingsworth companies for the building of 34 sleeping-cars, and the Union Company has also perfected arrangements for the exclusive use of its cars upon the lines of railroad now controlled by the Richmond & West Point Terminal Company.

Proceedings of Societies.

American Society of Civil Engineers.

A REGULAR meeting was held at the Society's house in New York, November 7. The Secretary announced that Past-Presidents W. J. McAlpine, Julius W. Adams and George S. Greene had been elected to honorary membership; also the death of Springer Harbaugh, a Fellow of the Society.

The Secretary then read a supplementary or additional report of the Committee on Uniform Standard Time. This report referred to a resolution which had been offered recommending a treatise on Time and its Notation as a text-book for schools, and stated that, in the opinion of the Committee, it was beyond the province of the Society to recommend any such work. This report was approved.

A paper by Frederick Brooks, on Time Reform, was then read.

It had been announced that an abstract of the report of the Committee on the Proper Relation to Each Other of the Section of Railroad Wheels and Rails would be read, but as this report had been distributed to members in advance, the reading was dispensed with, and the subject was opened for discussion. Some remarks were made by Mr. Wellington, of the Committee, and the written and verbal discussion was then postponed.

The tellers announced that the following gentlemen had been elected members of the Society:

Jacob N. Barr, Milwaukee, Wis.; Carroll P. Bassett, Newark, N. J.; William Cain, Charleston, S. C.; William Crawford, Sault Ste. Marie, Ont., Canada; James Walter Grimshaw, George Richardson Hardy, New Haven, Conn.: Franklin Rifle, Wallula, Wash.; Benjamin B. Smith, Charleston, S. C.; Frank Sherman Washburn, Chicago, Ill.; George Blinn Francis, Providence, R. I., and Henry Newton Francis, Providence, R. I.

Of these members Messrs. George B. Francis and H. N. Francis were transferred from junior to full membership.

Engineers' Club of Philadelphia.

A REGULAR meeting was held in Philadelphia, October 20. The following were elected members:

Charles H. Davis, William E. Good, James Murray Africa, E. A. Herring, H. Kauffman, Jr., James D. Moffet, R. Taylor Gleaves, and Charles Lundström.

The Committee to which was referred communications from the Western Society of Engineers and the Engineers' Club of Kansas City, in relation to design and inspection of highway bridges, presented a report recommending that a State Engineer should be appointed in each State who should have a general supervision of bridge structures, and that plans and strain sheets of bridges should be open to inspection. The Committee also recommended co-operation with other societies on this point, with a view of obtaining necessary legislation.

Mr. H. W. Spangler presented a paper on Multiple Expansion Engine Cards; this was followed by a short discussion. Mr. C. A. Lundstrom presented a paper on the Theory of Elastic Curves.

Mr. R. P. Snowden exhibited two specimens of old rails, a small and a large section.

The small rail is a piece of the first rail used by the Camden & Amboy Railroad, weighing about 20 lbs. per yard. This rail was laid on a beveled stringer, and spiked only on the outside of rail. About eight miles of this was laid from Cooper's Creek eastward. It was found unsuitable, causing many accidents. No splice was used, and the ends curled up, making "snake-heads," as remembered by some of our older members. It was replaced by English rail, 40 lbs. per yard, of a pattern similar to the old 67-lb. rail of 1878.

The large section is a piece of 7¼-in. rail, laid about 1847, near Bordentown shops, Ernston and Camden. It was of slightly differing sections, weighing about 90 lbs. to the yard, and was put down as an experiment. It was laid with wooden joints. The experiment was unsuccessful, the height of rail making it impossible to keep it from turning over, even with the wooden brace blocks which were put on soon after the rail was laid.

Some discussion took place over these specimens.

The Secretary exhibited for Mr. F. H. Taylor a section of a hand-rail, taken from a bridge over a railroad track and sent to illustrate the effects of gases, etc., from smoke-stacks upon iron, the metal showing very little rust or injury from weather and exposure.

The Secretary exhibited specimens of blue prints made on Linaura, a new prepared linen, of apparently excellent quality and almost unlimited durability, showing excellent blue color, very white lines, and white back.

A REGULAR meeting was held in Philadelphia, November 3. Mr. Henry M. Sperry presented an illustrated paper on the Details of Interlocking Switches and Signals.

Professor C. Herschel Koyl followed with an illustrated description of his Parabolic Semaphore. The Secretary exhibited for Mr. Gaylord Thompson 15 photographs of the work in progress on the new Croton Aqueduct.

Professor L. M. Haupt presented a description of the plan proposed by M. Caland, for the improvement of the bar of the Rio Grande do Sul in Brazil by the use of jetties in bars. The total length of these jetties is about five miles, the estimated cost $8,000,000 without dredging. The subject was discussed by a number of members, and the general opinion was expressed that the use of parallel or convergent jetties, as proposed by M. Caland, would merely push the bar seaward without permanent results. The cases of Aransas Pass in Texas and the harbors of Newburyport and Nantucket were cited as instances.

The Iron City Engineering Society.

A MEETING was held in Pittsburgh, Pa., November 8, for the purpose of forming a new scientific association, to be known as the Iron City Engineering Society. William Hazlett acted as Chairman and N. J. Mitchell as Secretary, the latter with H. E. Kellar and George R. Ward being appointed to draft a constitution.

The movement is a national one, and is intended for young men from 18 to 25 years of age who are actively engaged in metallurgy, civil and mechanical engineering, and electrical work of any kind. It is intended to secure rooms in some central location to be supplied with library, reading-room, cabinets, etc., and it is expected that the society will supply a much-felt want among the younger scientists in affording an opportunity for freer discussion of the matters in which they are immediately interested than can be obtained by them in the older societies.

Engineers' Club of Cincinnati.

THE fifth regular monthly meeting of the Club was held October 3. Three new members were elected, increasing the membership to 67.

Mr. G. Bouscaren presented an interesting description of the works he is now constructing to secure a water supply for the city of Covington, Ky. They consist (1) of a pumping plant and supply aqueduct on the left bank of the Ohio River, about one mile above the mouth of the Little Miami; (2) of the reservoir on the bluffs above, three-fourths of a mile from the pumping-house and four miles from the center of Covington, from which it is separated by the Licking River; and (3) of the force-pipe leading into the reservoir and the distributing mains leading therefrom.

The water will be taken from the Ohio River into the well of the pumping-house, through a circular arch of masonry 4 ft. in internal diameter and 158 ft. long, calculating to supply a pumping plant of 20,000,000 gallons in 24 hours.

The reservoir is formed by damming a branch of Three Mile

Creek below one of its bifurcations; partition dams across each fork dividing the reservoir into three basins.

The dams are of earth, the water slope being 3.1 and faced with puddle. The sides of the basin have a uniform slope of 3.1, which, with the bottom, is revetted with concrete.

A 30-in. force-pipe of graduated thickness (1¼ in. to 1 in.) leads to the reservoir, ascending the river bluff with an average grade of 20 ft. in the 100. A 30-in. distributing main leads from the reservoir to Covington (19,873 ft.).

The total cost of the work is $979,000.

THE sixth regular monthly meeting of the Club was held November 7. Seven applications for membership were presented and one member elected, increasing the membership to 68.

Colonel William E. Merrill addressed the Club, his subject being Movable Dams in General and the Davis Island Dam and Lock.

He briefly defined movable or adjustable dams as those which can be lowered during high stages of water and raised into position again when the supply of water is so small as to require pooling, to serve the purpose of navigation.

He discussed various French systems of movable dams, also the American "Bear-Trap," which utilizes hydraulic pressure, and is much used in lumbering regions to pass lumber down streams on artificial waves.

At Davis Island, in the Ohio River, five miles below Pittsburgh, Colonel Merrill has constructed a movable dam in four sections, having an aggregate length of 1,223 ft.

Although the Davis Island Dam has been in successful operation for three years, the exceptionally large quantity of driftwood, and occasionally of ice in this part of the river, has given so much trouble that a bear-trap is now under construction in the middle of the dam, to give an opening for the passage of the drift and ice. The lock rendered necessary by this dam is 110 ft. wide to allow the passage of four coal barges abreast. Its length is 600 ft. between gates. The ordinary miter gates being deemed inapplicable to a lock of such great width, the lock is closed at either end by a single gate 114 ft. long. These gates are operated by steam, moving on rollers into recesses in the landward wall of the lock. There are 14 filling culverts, each 54 in. diameter and closed by a circular balanced valve on a vertical axis, half in the river wall and half in the upper gate recess. The lock is emptied by seven 54-in. culverts in the lower gate recess and fourteen 38-in. openings in the lower gate. The last are operated by hand, all the rest by hydraulic pressure. The lock can receive at one time a tow-boat, 10 coal barges, and two fuel flats, while six passenger steamboats can be locked through at one lockage.

Engineers' Club of St. Louis.

THE first meeting of the season, November 7, was devoted to a supper in honor of the twentieth anniversary of the founding of the Society, which was largely attended and much enjoyed.

At the meeting of November 21 a paper on Smoke Prevention was read by Mr. Robert Moore and discussed.

The programme of the meetings for the season includes a number of interesting and valuable papers. The annual meeting will be held December 5.

Montana Society of Civil Engineers.

A REGULAR meeting was held in Helena, Mont., October 20. A committee was appointed to co-operate with committees of other societies, in the matter of Reform in the Construction and Inspection of Highway Bridges. A committee was also appointed to report on the dangerous crossings of some of the streets in Helena by the new Motor Line.

Mr. E. O. Goodridge read a paper on the Ingersoll Rock Drill, with special reference to its use in the construction of the Wickes Tunnel. This paper was discussed by the members present.

Engineers' Club of Kansas City.

A REGULAR meeting was held November 5, 1888, President W. B. Knight in the chair.

Mr. W. H. Breithaupt read for the Committee on Highway Bridge Reform the draft of a law prepared to be presented with a memorial to the State Legislature.

The Secretary announced several contributions to the library.

A paper on Electric Railroads was read by Mr. T. F. Wynn, and discussed by members present.

The programme for the winter is as follows:

December 3. The Steam Engine; its Beginning, Growth and Place in the Industries of To-day, by C. A. Burton.

December 5. Reports of Officers and Committees. Nomination of Officers for 1889.

January 7. Election of Officers for 1889. Address of Retiring President, William B. Knight.

January 21. Electric Railroads, by A. N. Connett.

February 4. The Details of Iron Highway Bridges, by E. W. Stern.

Technical Society of the Pacific Coast.

AT a regular meeting held in San Francisco, November 2, E. J. Molera in the chair, Marsden Manson, Chief Engineer of the San Francisco Harbor Commission, read a very interesting paper on the Swamp Lands of California. He briefly reviewed the manner in which the lands had been acquired by the State from the Federal Government, and the subsequent legislation in this State in reference to their disposition. The swamp lands are divided into three classes—those bordering the bays, those along the deltas of the rivers, and those bordering the lakes. Of salt marsh lands there are about 320 square miles. In all about 203,000 acres have been reclaimed on the bays, and 1,000,000 acres along the rivers. About $14,000,000 has been spent by the Government and by individuals in reclaiming these lands. Mr. Manson then reviewed the work that is being done. He stated that nowhere in this country is there such a large dredging plant, and that the amount of earth being handled was next to that on the Panama Canal. He regretted that there was not a general system under which it was being done. Each company or individual was going on independently of everybody else, and although they were in dead earnest and have vast sums at stake, he feared that they were frequently working at cross-purposes so far as the general success of the reclamation of large districts was concerned.

Western Railway Club.

THE regular monthly meeting was held in Chicago, October 23. Mr. J. N. Barr was elected Second Vice-President. A report was received in favor of publishing the proceedings in pamphlet form. This report was approved and the Committee directed to have them published. It was resolved to fix the date of the meetings the third Tuesday of each month.

The discussion of Mr Hickey's paper on the Circulation of Water in Locomotive Boilers, which was read at the September meeting, was continued by Messrs. Hickey, Forsyth, Barr, Slack, Cushing and others.

The subject of Materials for Car Construction was then taken up, and was introduced by Mr. Barr, who spoke with especial reference to Wheels. Messrs. Forsyth, Verbryck and other members continued the discussion.

The meeting was closed by a short discussion on the Steam Heating of Cars, in which the merits of the Sewall, Baker and other systems were presented.

AT the regular monthly meeting of this Club in Chicago, November 20, the subjects for discussion were Combustion, opened by Mr. C. M. Higginson, of the Chicago, Burlington & Quincy Railroad.

Wheel and axle for 60,000-lbs. cars; size and quality.

Mr. G. W. Ettenger read a paper upon the use of Iron as a Material for Building Cars.

Franklin Institute.

THE programme for the December lectures is as follows:

December 3. Introduction to Course on Chemistry; Dr. Persifor Frazer.

December 10. Edison and his Inventions; W. J. Hammer, of Boston.

December 17. Some New Phenomena in Acoustics; Professor W. Le Conte Stevens.

The Committee on Science and the Arts desire to call attention to the two medals at their disposal: 1. The Elliott Cresson gold medal either for some discovery in the arts and sciences, or for the invention or improvement of some useful machine, or for some new process, or combination of materials in manufactures, or for ingenuity, skill or perfection in workmanship.

2. The John Scott medal, with premium of $20 in gold for useful inventions.

Upon request therefor, from interested parties, made to the Secretary of the Franklin Institute, full information will be sent respecting the manner of making application for the investigation of inventions and discoveries; furthermore, the Committee on Science and the Arts will receive and give respectful consideration to reports upon discoveries and inventions, which may be sent to it with the view of receiving one or the other of the awards herein named, and full directions as to the manner and form in which such communications should properly be made, will be sent on application.

American Street Railway Association.

AT the convention held in Washington, October 18, the following officers were elected: President, George B. Kerper, Cincinnati; First Vice-President, Jesse Metcalf, Providence, R. I.; Second Vice-President, Henry Hurt, Washington; Third Vice-President, W. H. Martin, San Francisco; Secretary, W. J. Richardson, Brooklyn, N. Y. Executive Committee, Charles B. Holmes, Chicago; John Scullin, St. Louis; James H. Johnston, Savannah, Ga.; Henry A. Sage, Easton, Pa.; Edward J. Lawless, Kansas City, Mo.

American Institute of Architects.

AT its annual convention held at Buffalo, N. Y., in October, the following officers were elected: President, R. M. Hunt, New York; Secretary, A. J. Bloor, New York; Treasurer, O. P. Hatfield, New York. Board of Trustees: E. T. Littell, N. Le Brun, George A. Frederick, W. W. Clay. Committee on Education: W. R. Ware, N. C. Ricker, J. McLaughlin, W. G. Preston. Committee on Publication: T. M. Clark, Charles Crapsey, W. R. Briggs, G. C. Mason, Jr., W. G. Preston. Secretary for Foreign Correspondence: R. W. Gibson.

Master Car-Builders' Association.

LIST of subjects, with the committees appointed to report thereon, at the Annual Convention of the Master Car-Builders' Association, to be held June, 1889.

1. To Formulate a Code of Rules for the Interchange of Passenger Cars, including Sleeping, Parlor, Chair, Baggage and Express Cars.—T. A. Bissell, Wagner Palace Car Company, Buffalo, N. Y.; John W. Cloud, New York, Lake Erie & Western, Buffalo, N. Y.; Eugene Chamberlain, New York Central & Hudson River, East Buffalo, N. Y.
2. Standard Journal-box Lid for a Sixty-thousand pound Car and a Standard Lid for a Forty-thousand pound Car.—J. W. Marden, Fitchburg, Boston, Mass.; William McWood, Grand Trunk, Montreal, Canada; L. Packard, New York Central & Hudson River, West Albany, N. Y.
3. Standard Brake Gear for Air-Brake Cars, with a Brake Shoe for Iron Beam.—E. B. Wall, Pittsburgh, Cincinnati & St. Louis, Columbus, O.; George Hackney, Atchison, Topeka & Santa Fé, Topeka, Kan.; Godfrey W. Rhodes, Chicago, Burlington & Quincy, Aurora, Ill.
4. Journal Lubrication and Best Practice for Economizing Oil.—John W. Cloud, New York, Lake Erie & Western, Buffalo, N. Y.; H. Roberts, Chicago & Grand Trunk, Detroit, Mich.; J. N. Lauder, Old Colony, Boston, Mass.
5. Buffers and Carrier Irons for the Master Car-Builders' Type of Coupler and a Standard Length of Draw-Bars.—Charles F. Schroyer, Chicago & Northwestern, Chicago, Ill.; E. W. Grieves, Baltimore & Ohio, Baltimore, Md.; E. B. Wall, Pittsburgh, Cincinnati & St. Louis, Columbus, O.
6. Car Heating and Lighting. (This Committee was instructed to select a steam coupler to be submitted to letter-ballot for adoption.)—Frank L. Sheppard, Pennsylvania Railroad, Altoona, Pa.; R. D. Wade, Richmond & Danville, Washington, D. C.; Robert Miller, Michigan Central, Detroit, Mich.
7. Wheels. (This Committee was instructed to ascertain from the members of the Association whether the recommendations of their report would be acceptable to them, and from the replies received and the further experience which they may get during the coming year, to formulate a report, with recommendations, which can be submitted to the next meeting of the Association for letter-ballot, their recommendations to be adopted as a standard, if they meet the approval of the Association.)—J. N. Barr, Chicago, Milwaukee & St. Paul, Milwaukee, Wis.; John Kirby, Lake Shore & Michigan Southern, Cleveland, O.; George F. Wilson, Minneapolis & St. Louis, Minneapolis, Minn.
8. Standard Axle for 60,000 lbs. Car. (This Committee to report a form and the dimensions for such a standard axle at the next Convention.)—Godfrey W. Rhodes, Chicago, Burlington & Quincy, Aurora, Ill.; John S. Lentz, Lehigh Valley, Packerton, Pa.; R. McKenna, Delaware, Lackawanna & Western, Scranton, Pa.

Interstate Commerce Commission.

THE following circular has been issued by the Commission:

"The Bureau in charge of the Auditor will hereafter be known as the Bureau of Rates and Transportation, Auditor C. C. McCain remaining at the head thereof.

"In view of the importance of providing for an exhaustive compilation of statistics from the annual reports of carriers, and the great amount of detail work involved, a Bureau of Statistics has been established which is in charge of Professor Henry C. Adams, Statistician.

"All freight tariffs, passenger tariffs, classifications, rate sheets, circulars, and other printed or written matter relating to rates, together with all contracts, agreements, and traffic arrangements which are required to be filed with the Commission under Section 6 of the Act to Regulate Commerce, and correspondence relating thereto, will be addressed as heretofore to C. C. McCain, Auditor, Interstate Commerce Commission, Washington, D. C.

"Annual reports of carriers under Section 20 of said act, and correspondence relating thereto, will be addressed to Henry C. Adams, Statistician, Interstate Commerce Commission, Washington, D. C."

OBITUARY.

A. W. LANGE, who died at Roanoke, Va., November 1, was born and educated as a civil engineer in Sweden. After serving for several years on a Swedish railroad he came to this country in 1879, and has since been employed on various works, including the Hudson River Tunnel, the Atchafalaya Bridge on the Texas & Pacific Railroad, the Chestnut Street Bridge, in Philadelphia, and the Norfolk & Western Railroad.

GEORGE D. SPECHT, who died in San Francisco, November 2, aged 37 years, was born in Germany; educated as a civil engineer, and served for a short time on the Austrian State railroads. In 1879 he went to California, where he was employed as Engineer of the Sutro Tunnel, and afterward Assistant Engineer of the Spring Valley Water Works. Mr. Specht was one of the founders of the Technical Society of the Pacific Coast, and a very active member of that Association.

FREDERICK A. POTTS, who died in New York, November 9, aged 52 years, was for many years a prominent and widely-known coal operator and dealer. He was President of the New York, Susquehanna & Western Railroad, which was reorganized and extended under his charge, and was also largely interested in the New Jersey Central Railroad, in which he was a director.

PERSONALS.

W. H. LEWIS is now Master Mechanic of the Chicago, Burlington & Northern Railroad.

H. M. SMITH is now Chief Engineer of the Rome & Decatur Railroad, now under construction.

JOSEPH M. ROGAN is now Western Agent of the Baker Heater Company, with headquarters in Chicago.

Mr. J. E. BLUNT, late Division Engineer, succeeds Mr. H. G. Burt as Chief Engineer of the Chicago & Northwestern Railroad.

PROFESSOR HENRY C. ADAMS, of the University of Michigan, has been appointed Statistician to the Interstate Commerce Commission.

F. COLLINGWOOD is now a member of the Commission appointed to inspect and report on the masonry of the new Croton Aqueduct.

F. B. SHELDON has been appointed Chief Engineer of the Columbus, Hocking Valley & Toledo Railroad, with office in Columbus, O.

B. F. BOOKER is now Assistant Engineer in charge of main-

tenance of way, buildings, and water service of the Gulf, Colorado & Santa Fé Railroad.

WILLIAM HUNTER has been appointed Resident Engineer of the Atlanta & West Point Railroad and the Western Railroad of Alabama, with office at Atlanta, Ga.

HORACE G. BURT, late Chief Engineer of the Chicago & Northwestern Railroad, has been appointed Chief Manager of the Fremont, Elkhorn & Missouri Valley Railroad.

J. C. S. TABER has been appointed Chief Engineer of the Pomeroy, Middleport & Syracuse Street Railroad, a steam road 10 miles in length at Pomeroy, O. The New York office of the Company is at 44 Broadway.

ALPHONSE FTELEY, late Consulting Engineer, is appointed Chief Engineer of the Croton Aqueduct Commission, New York City, in place of B. S. CHURCH, who has resigned and is appointed Consulting Engineer.

W. W. STEARNS, late of the New Jersey Central Railroad, is now Superintendent of the Eastern Division of the New York, Lake Erie & Western Railroad, succeeding Mr. J. H. BARRETT, who has been appointed Superintendent of Transportation.

T. L. CHAPMAN, formerly Superintendent of Motive Power of the Chesapeake & Ohio Railroad, is now Assistant General Manager of the Safety Car Heating & Lighting Company of New York, and will have especial charge of the Company's relations with the railroads.

WILLIAM H. HOLCOMB has been chosen Vice-President of the Union Pacific Company, and will have the direct management of the company's lines, succeeding the late Thomas J. Potter. Mr. Holcomb was formerly on the Chicago, Burlington & Quincy, then on the Chicago, Burlington & Northern, and for a year past has been General Manager of the Oregon Railway & Navigation Company.

R. H. SOULE, recently General Manager and formerly Superintendent of Motive Power of the New York, Lake Erie & Western Railroad, has been appointed General Agent of the Union Switch & Signal Company, Swissvale, Pa. He will, among other duties, have charge of the sale and introduction of the new Westinghouse Buffer, the manufacture of which the company has added to its other undertakings.

D. H. NEALE has resigned his position as Associate Editor of the *Railroad Gazette*, and sailed for England, November 20. He expects to remain in that country, where he has accepted an excellent position. Mr. Neale has been connected with the *Railroad Gazette* some five years, and has done much excellent work. He is well known as a mechanical engineer of experience in almost all parts of the world, and as a writer of ability.

NOTES AND NEWS.

Proposed Dam across the Rio Grande at El Paso.—Major Anson Mills, of the Tenth Cavalry, at present stationed at Fort Grant, Ariz., has prepared a project to construct a dam across the Rio Grande, four miles above El Paso, Tex., at a place where the bluffs come within 400 ft. of each other and consist of solid rock, and where the bed of the river is also rocky. He proposes to build a dam 60 ft. high of stone and Portland cement, and thus create a lake 14 miles long. This would hold water enough to permanently irrigate the Rio Grande Valley on the Mexican as well as the American side of the river. An irrigating canal could thus be carried past the city of El Paso 70 ft. above its level. The water could be utilized for hydrants and fire-plugs, as the pressure would be ample. The lake thus formed would be from six to eight miles wide and cover 50,000 acres of land, which is not settled and is mostly owned by private parties. This would have to be purchased or condemned by legal process. The plan is very favorably received by the citizens of El Paso, and will probably be acted upon. It would also supply water-power to run all the factories in El Paso. Major Powell, Director of the United States Geological Survey, is said to approve the plan as practicable, and he proposes to establish a station to measure the flow of the river and determine the amount of sediment. It is proposed to make the dam an international affair.

Swedish Rapid-Fire Gun.—At the Copenhagen Exhibition is shown the first specimen of a new Swedish rapid-firing gun, designed by Mr. Harald Thronsen, and manufactured at the large and celebrated establishment of Finspongs, Styckebruk, Sweden. It is capable of firing 18 shots per minute with one man, while with two men it has a capacity of one shot every other second, or 30 shots per minute; caliber 47 millimeters; length about 52 calibers, and the distance from the base of the projectile to the mouth of the barrel 40 calibers. The muzzle velocity is 2,141 ft. (657 meters) per second, with a charge of 750 grammes of Swedish field-artillery powder; the maximum pressure in the barrel has been 2,300 atmospheres. The mechanism is both simple and strong.

Austrian Locomotive Building.—The Vienna papers note that a number of orders for new locomotives have recently been given with the approval of the Government. The Imperial Austrian State Railroad has ordered from the Wiener-Neustadt Works four fast passenger locomotives, two eight-wheeled coupled freight engines, three light locomotives for branch service, and two four-wheeled tank engines; from the Floridsdorf Locomotive Works four six-wheeled coupled engines, one eight-wheeled coupled freight engine, and four tank engines; from the Ringhoffer Works at Smichow 11 six-wheeled tank engines.

The Kaiser Ferdinand Railroad has ordered from the Wiener-Neustadt Works 14 six-wheeled tank engines. It is stated that contracts are now pending for not less than 125 engines for the new branch railroads (*localbahnen*).

The Champerico & Northern Transportation Company of Guatemala.—A concession was granted, in 1881, by the Government of Guatemala to Messrs. J. H. Lyman, D. P. Fenner, and T. B. Bunting, citizens of the United States, to build a railroad between the port of Champerico, on the Pacific coast of the Republic, to Retalhulen, a point about 28 miles in the interior.

The concession was for the term of 99 years from the date of the opening of the road to public traffic. For a term of 25 years from the same date the road was to be free from taxation and maritime duties, and foreign employés to be exempt from taxation and military service. During the same term also the road is to be protected by the Government from any railroad competition within a distance of 15 Spanish leagues on either side of the line. The right of way was also conceded and station grounds given by the Government, together with free use of its telegraph during the construction of the road and free use of the mails for 25 years for the business purposes of the road. A subsidy of $700,000 in Guatemalan currency was given to the enterprise, to be issued in non-interest-bearing bonds receivable at the custom-house of the Republic in payment of a certain percentage of all duties. A maximum tariff of freight and passenger rates was fixed by the concession, and the road is obliged to carry the mails free and Government employés on duty at half the regular rates.

The road was formally opened for traffic July 4, 1884. Its total cost was about $750,000 in gold. The capital stock of the company is $1,000,000.

From Champerico to Caballo Blanco, a distance of 15½ miles, the elevation attained is 275 ft., and from this point to Retalhulen, 11¾ miles, the total rise is 500 ft.

Back of Retalhulen the country rises toward the great central ridge, which forms the main part of Central America, and there is a large extent of fine country producing coffee and other products which are carried to Retalhulen by ox-carts and mules.

Quezaltenango, the second city of Guatemala, is 40 miles from Retalhulen, and all its business to and from the sea-coast is done through that point and over the railroad.

Silicon Steel.—At the recent meeting of the British Association for the Advancement of Science, a report was presented on the Influence of Silicon on the Properties of Steel. The report last year summarized the results obtained by varying the quantity of silicon added to the purest variety of iron met with commercially, and it was then shown that silicon rendered the metal quiet in the mold, and that in the proportions employed the metal was tough when cold and welded well. The elastic limit and the tensile strength were both increased by the presence of silicon, while the elongation and contraction of area were diminished; the appearance of the fracture also changed from silky to crystalline, and with over 0.13 per cent. of silicon the metal became so red-short that the ingots crumbled to pieces under the rolls. The present report deals with the results obtained by adding silicon to ordinary basic metal. The method of procedure consisted in adding to a weighed quantity of silicious iron melted in a crucible about 40 lbs. of molten metal taken from the ladle about the middle of a cast. After allowing the contents to stand for a minute, the metal was poured into a second crucible to solidify.

In the works tests, all the specimens rolled well, and with one exception behaved satisfactorily under the hot test. The cold or bending test was also satisfactory with the exception of one, in which the phosphorus present was exceptionally high. The presence of silicon has no ill effect upon the welding prop-

erty. The limit of elasticity and the breaking load are higher than usual, while the extension and reduction of area are rather lower than is common with this class of metal. The results are summarized by the committee as follows: On adding silicon in proportions not exceeding 0.5 per cent. to ingot iron containing manganese, the metal rolls well, and does not show any signs of red-shortness; it welds perfectly with all proportions of silicon, and (with the somewhat doubtful exception containing 0.5 per cent.) is not brittle when cold. With less than about 0.15 per cent. of silicon the limit of elasticity, the breaking load, the extension and reduction of area, are but little, if at all, appreciably affected by the presence of silicon; but with more than 0.15 per cent. of silicon the limit of elasticity and breaking load are increased, while the extension and reduction of area are distinctly decreased by the presence of silicon. The effect exerted by silicon in increasing the tenacity of ingot iron is not nearly so great as that of carbon. The relative hardness is very slightly affected by the proportions of silicon used in these experiments.

Electric Haulage in the Anthracite Mines.—The introduction of electricity as a motor for underground haulage in the anthracite mines of Pennsylvania is a matter of great interest to mining engineers, since its success or failure will have much to do with its application to the various operations now consuming steam, such as pumping, drilling and hoisting.

The common method of hauling the coal to the main outlets is still by mule power, replaced in some instances, however, by mine locomotives, and in one case only, to the writer's knowledge, in the Schuylkill region, by the endless rope system.

Mine locomotives are, however, very objectionable, and even in some of the recent leases prohibited, on account of the danger to good ventilation caused by the noxious gases thrown off during the combustion of their fuel. In consequence of this they can only be used in the gangways carrying the return current. The electric locomotive avoids this, as well as other objections, since the generator is entirely outside of the mine. It is only limited in its use by the extent of the tracks supplied with the conductor rail or wire.

The Lykens Valley Coal Company at its mines in Dauphin County, Pa., has introduced the electric locomotive with, it seems, considerable success. The road here is 6,300 ft. long, supplied with a third rail carried along the side of the gangway. The average load is 20 cars per trip, or 850 tons per day, equivalent to 1,040 mile-tons per day. The Union Electric Company, which furnished this plant, gives the daily expenses of running the locomotive as $5.71, or a cost per mile-ton of 0.67 cents. This, they claim, can be reduced by the use of better graded roads and heavier mine wagons to 0.40 cents per mile-ton. The writer, in a former paper, gave the relative costs of mule and steam locomotive haulage at Kalmia Colliery, and now introduces them here for comparison with electricity as follows:

	Mule.	Steam.	Electricity.
Cost per ton-mile....	1.82 cents.	0.60 cents.	0.40 to 0.67 cents.

It should be borne in mind that the costs as regards mule and steam power are based upon the prices of 1882, while the estimate for electricity is for 1887, consequently the comparison is not entirely a just one; but it is made to show that we may expect under favorable circumstances electric haulage to at least do the work required as cheaply as steam power, and with less attendant danger to the mine.—*A. W. Sheafer, before Engineers' Club of Philadelphia.*

Underground Forts in Belgium.—In a recent number of *La Nature* Colonel Hennebert, of the Belgian Army, describes underground forts, which have come into use in Belgium, as one of the principal methods of national defense. One of these underground forts is like an enlarged molehill, and is built of concrete. Measuring 50 meters in length by from 30 to 40 in width, it is about 12 meters below the surface of the ground, and its greatest height above the earth is no more than three or four meters. It presents the appearance of an elliptical cap placed on the ground, and is scarcely visible to the eye of an observer. At the center of this artficial rock are three armored towers, each with two heavy guns. There are also four small forts, which are pulled in and run out at pleasure, each armed with two rapid-firing guns. At three suitable places there are armored points of observation, from two of which at night the electric light can be flashed to watch the operations of the enemy. Below this surface the earth is hollowed out in the form of a huge well with armored sides, which is divided up into sections, each part protected with heavy armor, one part for provisions and ammunition, another for machinery, which includes the dynamos and accumulators for the lighting of the whole fort, hydraulic machines for working the movable turrets and sending them ammunition, pumps for supplying these machines with water, and a series of ventilators to keep the air pure. Communication with the outer world is made by a subterranean gallery, the length of which varies according to surrounding circumstances. The ceiling of this gallery is from 8 to 10 meters below the surface. To gain access to the fort a hydraulic piston is worked, and this raises a ladder which runs along the whole length of the fort, and lowers the door of the outlet, which is protected by armor 20 centimeters in thickness, and is under the fire of two of the movable forts. All movements, such as changes of guard, arrivals of supplies, etc., are reported by telephone or telegraph. The guard does not work the hydraulic piston, except at command, and when the sentries in one of the movable forts have reconnoitered the visitors. Finally, the gallery communicating with the outer world is strongly fortified by an armored door defended by two mitrailleuses. One of the greatest objections by generals to forts, that they absorb numbers of men who are wanted in the field, cannot be urged against these subterranean forts, for the garrison consists of 30 or 40 mechanics and specialists only, whose absence would not appreciably weaken the regiment from which they are drawn. The cost of one of these forts is only about $500,000.

Sewage Scheme at Manchester.—The present plan pursued by the city of Manchester, England, is to empty its sewage into the three rivers passing through it, the Irwell, Irk, and Medlock. Owing to the enforcement of the River Pollution Act of 1876, it has become imperative that the sewage should be collected and purified before being passed into the streams. The natural formation of the land in the city is such that sewers can be conveniently arranged so as to convey the sewage by gravitation toward the western boundary of the city. An inquiry was recently commenced in that city by an inspector for the Local Government Board, into a scheme of sewage interception and disposal designed by the City Surveyor, Mr. John Allison, C. E. The scheme is opposed by the representatives of various local authorities.

The sewage of Manchester is mainly of the domestic class, as is clearly shown by the figures of water consumption. These indicate that 13 gallons of water per head of the population are used for domestic, and seven gallons of water per head for trade and public purposes during every 24 hours. When the new supply of water from Thirlmere is obtained, it is estimated that a larger volume will be used, and it is therefore intended to provide for a daily use of 44 gallons per head. The scheme, as presented by the Rivers Committee, determines the maximum flow at 100,257,000 gallons in 24 hours, for which provision has to be made.

The ruling idea is that of dividing the city up into convenient drainage areas, each of which shall be provided with a main sewer of sufficient capacity; these drainage areas are collected into two groups, which comprise respectively the Irk and Medlock. There is no special engineering work in connection with the construction of these sewers, except in the case of one draining the Strangeways District at the point where it crosses the river Irk. This river is to be crossed by means of a specially designed iron box fitted under the arches. The gradients of the sewers within the city vary from 1 in 18.

At a point between the city boundary and the overflow, a sewer known as Brook's Sewer crosses the trunk sewer at a little higher level. It is therefore proposed at this point to construct a special chamber across which a flat iron pipe of full capacity can be carried, so as not to interfere with the flow of Brook's Sewer. The trunk sewer is between four and five miles in length, and terminates at the precipitation works. Special shafts are provided to permit of easy access being had to the syphon, in order to facilitate examination and cleaning in the event of choking. The precipitation of the sewage is conducted in 20 tanks, each 100 ft. by 60 ft., and 7 ft. deep. The total capacity of the tanks is 4,500,000 gallons. As the sewage approaches the works it terminates in a special chamber, which allows the heavier impurities in the sewage to be deposited. After passing this point the sewage is mixed with a certain volume of lime and alum, and after agitation the whole of the liquid passes into a chamber 188 ft. long, from which it flows into the first of each series of tanks. The method of emptying the sludge is as follows: The sill between each tank is arranged so that by lifting sluice boards at one side a channel is formed. When it is desired to shut off one tank, the sewage is carried along this channel and down each side of the tank on to the sill of the next tank, where it passes over in the usual way. In this way the sewage in the tank is run into a well from which it is raised by a pump, and again passed through the tanks. After the liquid sewage has drained off, a second and lower valve is opened, and the sludge is allowed to pass through a second pipe into a sludge well.

The estimated cost of the whole scheme is to be covered by an expenditure of $2,250,000 for sewers and works, and $200,000 additional for land.

Utilizing Old Ties in India.—The following method of utilizing condemned and disused sleepers for strengthening railroad tracks at the rail-joints will, we think, be of interest to all who are engaged in the construction and maintenance of railroads.

However perfect the mechanical fit may be between the contact surfaces of the rails and fish-plates and of the other fastenings, it is not so perfect as to entirely prevent deflection under heavy and rapid live loads. This deflection frequently develops into free play (especially when the fastenings are new), whereby extra pressure is thrown upon the joint-sleepers, and they, in turn, transmit the extra pressure to the ballast.

At this stage the ballast frequently gives way, and the two rails now resemble a girder of about 7-ft. span, with a fish-plate acting as a cover-plate, as represented in fig. 1.

It will be seen at a glance that enormous strains are thrown upon the joint fastenings, and that if the ballast is not promptly packed up, the safety of the line is jeopardized. There is, of course, the bending moment of the rail to be reckoned upon, but even this does not afford a safety margin. It is, therefore, evident that it would be well to increase the bearing area of the joint-sleepers. This could be done by widening them ; but as it is very inconvenient in practice to have special sleepers of any description, we have tried the following simple method, which is found to stiffen and steady the road very considerably, especially when new and on a new bank. A sleeper is placed

FIG. I

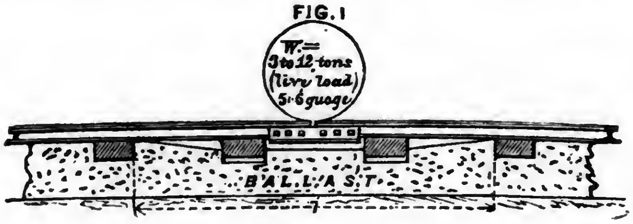


FIG. 2.

Longitudinal Section.

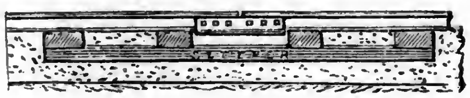


FIG. 3.

Cross Section.

longitudinally under the joint-sleepers, and notched to receive them, as in figs. 2 and 3.

Condemned sleepers can be utilized for this purpose, and on open lines, on which wooden sleepers are used, this tie-sleeper could be used at once, as there is doubtless a supply of sleepers in disuse from cracks, chair wear, and other faults, which would do very well for this purpose ; in fact, all could be utilized except those which are actually decayed from dry or wet rot ; but on most new lines the only sleepers available are those which are condemned under the specifications, and which can generally be had at a cheap rate ; these might be used in the worst parts of the line—that is, where the bank is likely to give trouble owing to bad soil, etc.

It would, however, in the interests of true economy, pay on new lines to use new sleepers (as well as condemned ones, if available) for this purpose, as the cost would be a mere bagatelle compared with the advantages and savings which would result therefrom.

The advantages attending this method are briefly :

1. The bearing or contact surface between sleepers and ballast under the rail ends is nearly doubled, and deflection of the joint-sleepers is prevented.
2. The joint fastenings are relieved of strains, and their life is prolonged.
3. The joint-sleepers are kept in their proper position, and, with some patterns of permanent-way, the creep of rails is prevented when such a tendency is set up.
4. A smoother and safer road.

There are many other minor advantages attending the use of this sleeper which practical railroad men will readily see.—*The Indian Engineer.*

The Samara-Ufa Railroad.—Great interest has been excited in Russia by the completion of the line from Samara to Ufa, on account of its being practically the first section of the future Siberian Railway. It is true that it is situated wholly in European Russia, not in Siberia, but the line was especially constructed, not for local purposes, but as a starting section of the Siberian communication with the river Volga and the railroads of Europe, and already the commencement has been sanctioned of the second section, situated in Siberia itself, stretching from Ufa to Zlataoust. The Samara-Ufa line extends from Samara on the Volga to the town of Ufa, at the foot of the Ural Mountains. The line differs from the northern Siberian Railway from Perm to Tiumen, *via* Ekaterinburg, in this important respect, that whereas the Perm line is totally unconnected with the Russian railway system, there being no line between Perm and Nijni-Novgorod, the Samara-Ufa Railway is in absolute touch with the entire railway system of Russia. In accordance with the new policy initiated by General Possiette, Minister of Ways of Communication, the line has been built by the State, and will be worked by Government officials. The line is 487 versts, or 325 miles, long. Its cost is estimated at 17,300,000 paper roubles, or 38,000 roubles ($19,000) per verst (⅔ of a mile), without rolling stock and rails, the latter costing 6,800,000 paper roubles, or 15,000 roubles ($7,500) per verst. The country for the most part is steppe—*i.e.*, flat prairie land, with few undulations. There is, however, a large bridge traversing the river Beirlie at Ufa, being 2,100 ft. long, divided into six spans of 350 ft. apiece. The constructor is V. S. Berezine, an assistant of Michaelousky in the construction of the Alexander Bridge (twice as long) over the river Volga at Sizran. Besides this colossal bridge there are 300 smaller ones, of which 11 range in length from 70 ft. to 210 ft. The whole of the materials used in the construction of the line are Russian, and no foreigners whatever have been employed in the undertaking. The number of stations on the line will be 25, or on an average one every 13 miles. This will show how slightly developed the country is. Only four small towns are touched on the way. When the Orenburg Railroad, in a parallel direction, was constructed a similar state of things prevailed, but numerous settlers followed the locomotive, and now the line is bounded by settlements throughout. It is expected that the same will occur with the Samara-Ufa line in due course. A great traffic is not anticipated until the line is pushed further into Siberia. According to current report the Government intends to construct the entire Siberian Railway itself, raising for that purpose loans from time to time, mainly in Russia. As industrial enterprise is very stagnant just now in Russia it is believed the public would readily subscribe to these issues of Siberian railway stock.

The Ship Channel from Montreal to Quebec.—An event of much interest to the people of Montreal was the official opening last month of the new St. Lawrence 27½-ft. ship channel from Montreal to Quebec, a distance of 160 miles. As early as 1825 this work had been spoken of and petitioned for, but it was not until 1838 that anything was really done.

From 1838 to 1867 the ship channel had been improved at various times, until at the latter date there was throughout the whole distance between Montreal and Quebec a minimum width of 300 ft. with a depth of 20 ft. at ordinary low water. Shortly after that the growing trade of the St. Lawrence and the increasing size of vessels demanded that the ship channel should be further deepened, and an act was passed by Parliament in May, 1873, authorizing the Government to contract a loan of $1,500,000 to defray the expense of completing the ship channel from Montreal to tide-water above Quebec to a depth of not less than 22 ft. at low water and a width of not less than 300 ft.

Operations were commenced in the spring of 1874 with one dredge and a stone-lifter, and contracts were entered into for the building of six large elevator or ladder dredges, and also for the purchase of tugs, scows and other plant required. The new plant was finished and set to work in the spring of 1875, and was kept steadily at work during the season of navigation of each year until the close of 1878, when a minimum depth of 22 ft. had been attained at all points except between Cap Levrant and Cap Charles, where it was necessary to take advantage of the tide. Up to that time there had been spent for new plant $523,902, and for working expenses $628,610, or in all, $1,153,512.

The channel in Lake St. Peter, the largest piece of dredging in any one place, is in all 17½ miles in length, 300 to 450 ft. in width, and involving the removal since the beginning of dredging in the present channel, in 1851 to 1882, of about 8,000,000 cubic yards.

No sooner had a depth of 25 ft. been reached than the Harbor Commissioners decided to prosecute the work still further, and in the following year, 1883, application was made to the Government and Parliament for a loan of $900,000 for the further deepening of the channel to 27½ ft. This was granted, and for the

past six seasons of navigation the work has been actively carried on, and it is now completed except at a few points, which can be finished by the time of low water next fall.

The growth, as shown in the following table, of the sea-going shipping trade at Montreal since the work of deepening from 20 ft. at low water to $27\frac{1}{2}$ ft. was begun indicates the great increase in tonnage that the city may expect:

	1873		1887	
	No.	Tons.	No.	Tons.
Steamships	242	245,237	600	807,471
Ships	72	65,823	7	8,684
Barks	164	75,594	68	43,275
Brigs	18	4,660	2	1,118
Brigantines	59	8,581	7	2,031
Schooners	149	12,583	83	8,194
Totals	704	412,478	767	870,773

It has been demonstrated that the tonnage of a port will increase as the cube of the depth that can be carried in. The depth of $27\frac{1}{2}$ ft. has only just now been attained, and its effect on the trade of Montreal is yet to come; but next year Montreal may expect to have or to exceed a million tonnage.

A Swiss Electric Railroad.—The electric cable railroad up the Burgenstock in Switzerland is interesting to electricians and engineers because of the novelty and skill which have entered into its accomplishment, and because of the extraordinary difficulties which have been surmounted. Hitherto it has been considered impossible to construct a funicular mountain railway with a curve, but the new line up the Burgenstock has achieved that feat under the superintendence of Mr. Abt, the Swiss electrical engineer. The rails, in fact, describe one grand curve formed upon an angle of 112 degrees, and by an arrangement of wheels for the cars known as the "System Abt," the journey is made as steadily and smoothly as upon any of the straight funiculars previously constructed. The Burgenstock being almost perpendicular, it would have been impossible to construct a railway upon the old plan. A bed has been cut for the most part out of the solid rock in the mountain side from the shore of the Lake of Lucerne to the height of the Burgenstock, 1330 ft. above its level, and 2,860 ft. above the level of the sea. The total length of the line is 938 meters, and it commences with a gradient of 32 per cent., which is increased to 58 per cent. after the first 400 meters, and this is maintained for the rest of the journey. A single pair of rails is used throughout, with the exception of a few yards at half distance to permit the two cars to pass. Through the opposition of the Swiss Government, each car is at the present time only allowed to run the half distance, and they insist upon the passengers changing, in order, they say, to avoid collision or accident.

The current is generated by two dynamos, each of 25 H. P., which are worked by a water-wheel of 125 H. P., erected upon the river Aar at its mouth at Buochs, three miles away. The current is conducted by means of insulated copper wires to a pair of electric motors, of the same power, which are placed at the head of the railway. The loss of energy in transmission is estimated at 25 per cent. The motors are connected by leather belting with two large pulleys on a countershaft, which is connected with a set of movable conical cogs, from which the big wheel over which the wire rope passes is driven. To give the rope adhesion it is wrapped under and over two smaller pulleys, and then for a second time over the larger wheel. The arrangements for applying the power are of the simplest character. Only one man is required to manage the train, and the movement of the cars is completely under his control. One dynamo is sufficient to perform the work of hauling up and letting down the cars containing 50 or 60 persons. With a switch the conductor regulates the amount of current according to his requirements. He communicates by electric signals with the man at the water-wheel when the cars are about to commence their journey, and the latter in turn regulates the water-power applied. A finger moving along a figured disc before him, by means of a millimeter screw, at the rate of a millimeter to every meter of the railway enables him to see the exact position of the cars on the line at any given moment of the journey, and he can increase or slacken speed accordingly. In addition to this the cars themselves give him a signal at stated points. For instance, at a distance of 1 meter and 15 meters respectively after the car leaves either the upper or the lower station, the flanges of the wheel pass over an electric plate, and a bell is rung in the machine-room. The same signs are given when they arrive within 15 meters and 1 meter of the half distance, so that the cars are themselves their own signalmen, and the driver knows exactly when to shut off power. At the end of the journey, completed in about 15 minutes, at an ordinary walking speed, the car moves gently against a spring buffer, and is locked by a lever without noise and without jolting the passengers.

The interesting undertaking has been carried out at a cost of $125,000. The water-wheel is also employed to light the whole of the hotel buildings and its grounds by electricity, and when the railway is not working, another dynamo pumps up spring water 1,000 ft. for use in the establishment.

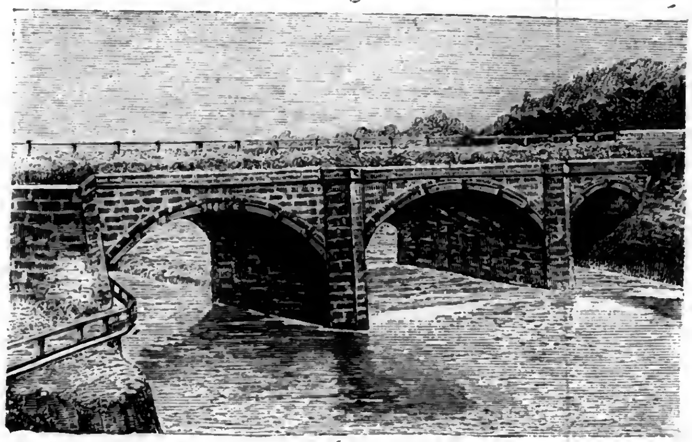
The motors derive their current from a set of accumulators at the station and not directly from the dynamos. This arrangement has probably been adopted not only for the sake of economy in the mains, but also to avoid possibility of accident arising from an interruption of the charging circuit.—*London Electrician.*

A Historic Bridge.—The Barton Aqueduct, which, in its day of completion, was the subject of awe and admiration of kings and princes, is now to give way before the Manchester Ship Canal, a yet more important undertaking, which increased and ever-increasing population and commerce have rendered desirable.

In 1757 the Duke of Bridgewater's attention was turned to the question of a waterway from the Worsley coal-pits on his Lancashire estate to Manchester. His first serious consideration seems to have been the difficulty of crossing the river Irwell. His first idea was to reach the ordinary level of the river by means of locks, but he finally decided the loss of time and the additional cost of working the canal traffic was too great.

The Duke secured the services of James Brinkley, an ingenious, honest and hard-working millwright, who advised him to abandon the idea of locks altogether and to carry the canal at one uniform level throughout. The proposition was so original and stupendous that we are surprised to find the Duke willing to listen to such a suggestion. But so great was his faith in Brindley that, in spite of the work entailed, we find that he again introduced a Bill before Parliament to extend his powers and enable him to construct the present aqueduct. This Bill passed in 1760, and the work was at once begun and actively pushed forward.

The Barton aqueduct, as will be seen from our sketch, consists of three semicircular arches, the center one having a span



of 63 ft. The total length of the aqueduct is about 600 ft., and the average width 36 ft. This aqueduct, which is shown in the accompanying illustration, is of interest, not only from the excellence of design, but from the fact that when it was built it was the only large canal bridge outside of China.

The new ship canal contract includes the removal of the whole of the three arches and the construction of a new aqueduct on a slightly different line. The difference of level between the Bridgewater Canal and the proposed shipway is 32 ft., the level of the Bridgewater Canal being unaltered, and that of the ship canal being 7 ft. higher than the old level of the river. It will be easily understood that, although a total height of 39 ft. was quite sufficient for the old barge traffic navigating the Irwell, it would be quite impossible for sea-going vessels to pass. To meet this difficulty Mr. Leader Williams, the Engineer of the Ship Canal Company, has designed a swinging caisson for the high level barge traffic, so arranged that when a vessel is about to pass up or down the ship canal gates are closed at each end of the caisson. This being done, the caisson becomes practically a detached portion of the canal, and is readily turned on its center, thus leaving an uninterrupted shipway. Provision is also to be made at each side of the new waterway for raising and lowering barges from and to the ship canal. For this purpose hydraulic lifts will be employed. At present the contractor, Mr. T. A. Walker, has not begun the construction of the new aqueduct, but the sections immediately above and below the bridge are being steadily pushed forward, and the scene on either side is one of great interest and activity.